A STUDY OF THE HISTORY, PRACTICE AND ECONOMICS OF FOREST NURSERIES IN SOUTH AFRICA.

By

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LIST OF APPENDICES.

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I wish to record my gratitude to the Secretary for Forestry, without whose co-operation most of this study could not have been completed. I am particularly grateful for his permission to use data from experiments conducted by me as Forest Research Officer, Cape Midlands, the enumeration of one of which was done by my successor, and data collected in a national census of state and private plantations conducted by his Department.

The willing co-operation of the Chief Forest Research Officer, Chief Regional Forest Officers, Regional Forest Officers and Foresters is gratefully acknowledged. I wish to thank registered and non-registered nursery owners who responded to my questionnaires; the South African Timber Grower's Association, Peak Timbers Ltd., South African Forest Investments Ltd., Twello Forestry Corporation and the Forestry Section of the Cape Town City Council, whose valuable assistance made the study of nursery costings possible.

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INTRODUCTION

A comprehensive critical study of forest nursery practice in South Africa has never been undertaken. Historical circumstances, often unrelated to silvicultural needs, have led to the use of techniques that have become traditional and are often accepted without consideration of their efficiency and costs. Much research remains to be done and this review is intended to serve as an introduction to an extensive field of investigation which it is hoped to explore further.

Nursery investigations serve a dual purpose. They indicate how healthier, more vigorous and viable transplants can be produced to accomplish the establishment of plantations. They also indicate how costs of production can be reduced at the beginning, and therefore the most vulnerable stage, of the long-term investment in forestry.

The history of the forest nursery industry in South Africa has been traced to show how existing methods came to be adopted and to establish the extent and indicate the possible future development of the industry. The conclusions have, as far as possible, been supported by numerical data.

To judge the systems of nursery practice applied in South Africa cost data from the major State and private nurseries have been obtained and analysed. The data are incomplete because overhead charges are not included, but they are relatively reliable and are considered suitable for comparing the different systems.

The nursery systems applied to Pinus species have also been tested experimentally at various plantations in the Cape Province. The critical transfer of plants from the nursery, where they are, in fact, nursed, to the field, where they have to develop independently, has been specially investigated in experiments. The results were assessed silviculturally, on the basis of survival, vigour and health after

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planting, and economically, on the basis of the relative costs of the establishment of stands by various methods.

This preliminary review of nursery practice in South Africa has yielded significant results that emphasize the need for further research in this field.

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CHAPTER I.

THE HISTORY OF THE FOREST NURSERY INDUSTRY.

The development of forest nurseries has generally been inversely proportional to the extent and value of a country's natural forests; those countries with few natural forests and inadequate timber supplies have frequently been the first to establish forest nurseries. Thus in Great Britain with approximately 7 per cent (FAO, 1958) of its surface area under forest, many forest nurseries were in use by the beginning of the nineteenth century (Stevens, 1928). Indeed the timber shortage in Britain caused John Evelyn, 300 years ago, to recommend, with detailed instructions, that plants to establish plantations be raised in nurseries (Evelyn, 1703). In North America with 39 per cent (FAO, 1958) of its land surface under forest of economic value, forest nurseries were unimportant until early in the twentieth century when the need to replant extensive, heavily exploited natural forests was appreciated (Toumey, 1931).

The species composing the natural forests also influence the need for nurseries. Where forests of desirable species exist the nursery is less necessary as other silvicultural techniques can be used to perpetuate them. East and Central African territories have considerable mixed hardwood forests, but plantations using nursery plants of exotic conifers have been started to supply the increasing demand for softwoods.

In South Africa the limited natural forest, less than 1 per cent of the surface area, which has been exploited destructively, has forced the country to afforest with fast-growing exotic species to supply essential hardwood and softwood.

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Forest nurseries have been increased and expanded to raise plants for the expanding afforestation, particularly since 1900. These nurseries today can produce approximately 56 million trees annually for commercial afforestation.

EARLY DEVELOPMENT OF NURSERIES - 1652 to 1875.

Historical records of tree nurseries in South Africa exist from the seventeenth century although the major development dates from the late nineteenth century. Jan van Riebeeck and Simon van der Stel started tree nurseries shortly after their arrival at the Cape. Spilhaus (1950) reports that van Riebeeck received "a cask of fir cones" in 1656 to raise trees for timber. Simon van der Stel is often referred to as the "tree planter". Fairbridge (1937) states: "Rustenberg was built (1686) at Rondebosch as a country-house for the Governor, and the centre of the tree planting industry. "Sacks of acorns were sent from Holland, and the kernels of stone and cluster pines from Italy and these germinated and sprang up as if by magic in the rich black soil....in 1687 it was recorded that 50,000 young trees were awaiting removal". For 200 years after these early efforts plants were raised for little more than farm woodlots, avenues and ornamental planting. Then after the discovery of diamonds, 1869, and gold, 1886, the colonization and economic development of the country was greatly accelerated and the first significant commercial afforestation began.

The history of afforestation and thus of nursery practice, in South Africa, is the history of the Forest Departments of the Cape Colony, of the Union and the Republic of South Africa. Although forest conservation was begun by the Forest Department of the Cape Colony in 1846, nursery work was not extended until J. Storr Lister was appointed "Superintendent of Drift Sand Plantations" in 1875.

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Lister, who had experience and training in the Indian Forest Department, established plantations of pine, wattle and gum by direct sowing in 1875, expending £344.9.0, on them in that year. No records exist of a large nursery in these early years, though small trials using nursery plants were made. Lister in his Annual Report for 1875, says, "Should these (nursery plants) succeed I consider it advisable in future to make nurseries of young plants near the drift, and transplant from them instead of sowing seed". Perhaps his trial plantings failed, in any event the practice of direct sowing Acacia seed, with the use of Cape Town's refuse as a mulch was continued, i.e. "of spreading the refuse (street sweepings and other Cape Town refuse) over previously sown tree seeds, the object being to prevent movement of the sand, to protect seedlings from the hot sun and to provide manure" (Lister, 1957).

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EUCALYPTUS GLOBULUS.

SPECIMEN FROM THE FIRST CROP OF TRANSPLANTS RAISED BY THE FOREST DEPARTMENT IN SOUTH AFRICA. GROWN AT WORCESTER PLANTATION NURSERY. MARCH-APRIL. 1876. FORWARDED BY THOS. PYE. IN CHARGE OF WORCESTER NURSERY. TO J. STORR LISTER ESQ., THEN SUPERINTENDENT OF PLANTATIONS. CAPE COLONIAL GOVERNMENT. AND LATER CHIEF CONSERVATOR OF FORESTS.

Photographed by courtesy of Mrs. J. Storr Lister, Kenilworth, C.P. April, 1935.

P.U. HERBARIUM No. 8677

PLATE I

Specimen of Euc. globulus raised by the Forest Department in the Worcester Nursery 1876. (Photo Dept. of Forestry 1963).

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DEVELOPMENT OF NURSERIES FOR COMMERCIAL AFFORESTATION-1876 to 1920.

In 1876 Lister established the first commercial plantation near Worcester. The Report on the condition of Crown Forests and Drift Sands for the year 1876 contains the following paragraph: "In the early part of the year, with the object of establishing a fuel plantation, 40 acres of land near Worcester were enclosed with a wire fence, within which was planted a hedge of thorny Lycium. The enclosure contains between forty and fifty thousand trees, (Eucalyptus globulus) some of which are six feet high, raised from seedlings transplanted from a nursery in the Drostdy ground, in which there are still some plants to spare" (Plate I). This is the earliest reference to an extensive forest nursery in South Africa, but little else is known of it. Evidently the trees were raised in paraffin tins: "Old Pye, the gardener at Firlands, (the Lister home at Rondebosch) was sent to Worcester with seed to raise and a truck load of paraffin tins in which to raise them". (Lister,1957).

By 1878 a nursery had been established at Uitvlugt on the Cape Flats and together with the Worcester nursery, raised and distributed 67,289 young trees of various species that year.

In 1881 the Forest Department of the Cape Colony was formed, with Comte de Vasselôt de Regné as Superintendent of Woods and Forests.

The Comte undertook a tour of the area under his command in 1882 and submitted a comprehensive report. One of his chief recommendations was that, "a nursery should be established in the vicinity of every district where felling is going on and particular care should be bestowed each year upon the collection of seeds of the best kinds".

The report recommended three main measures for the protection and enlargement of the forest estate:

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1. "The application of the best possible treatment to existing forest lands".

2. "The introduction of Timber trees among the bushes" (Fynbos areas).

3. "Planting trees on lands where forests are necessary".

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LIST OF TRANSPLANTS IN NURSERY AT TOKAI.

	BOTANICAL NAME.	COMMON NAME.	NUMBER.
1	Aberia Caffra.	Kei Apple.	4,000
2	Acacia horrida.	Thorn Tree.	600
3	Ailanthus glandulosa.	Ailanthus.	30
4	Angophora lanceolata.	Angophora.	525
5	Castanospermum Australe	Moreton Bay Chestnut.	300
6	Casuarina.	Beefwood.	12,500
7	,,	Filao.	7,000
8	,, tenuissima.	Beefwood.	1,800
9	Catalpa speciosa.	Catalpa.	180
10	Ceratonia Siliqua.	Carob.	500
11	Cupressus Lawsoniana.	Cypress.	100
12	,, macrocarpa.	,,	1,000
13	,, sempervirens.	,,	400
14	Dalbergia Sissoo.	Dalbergia.	200
15	Eriobotrya Japonica.	Loquat.	1,800
16	Eucalyptus botryoides.	Bastard Mahogany Gum.	1,400
17	,, calophylla.	West Australian Red Gum.	2,300
18	,, cornuta.	Yaté.	800
19	,, corynocalix.	Sugary Encalypt.	600
20	,, diversicolor.	Karri.	2,000
21	,, Globulus.	Blue Gum.	20,400
22	,, marginata.	Jarrah.	7,000
23	,, obliqua.	Stringy Bark.	4,400
24	,, resinifera.	Kino Encalypt.	350
25	,, robusta.	Mahogany.	10,500
26	,, rostrata.	Victorian Red Gum.	1,400
27	,, macrorrhyncha	,, Stringy Bark.	500
28	Hakia.	Hakia.	20,000
29	Larix Europea.	Larch.	60
30	Melaleuca leucadendron.	Paper Bark.	2,000
31	Melia Azedarach.	Syringa.	1,500
32	Morus alba.	White Mulberry.	65
33	Pinus Austriaca.	Black Austrian Pine.	100
34	,, Halepenis.	Aleppo Pine.	2,500
35	,, insignis.	Monterey Pine.	250
36	,, Pinaster.	Cluster Pine.	10,000
37	,, Pinea.	Stone Pine.	820
38	,, silvestris.	Scotch Pine.	150
39	Podocarpus Thunbergii.	Yellow Wood.	70
40	Populus monilifera.	Cotton Wood.	50
41	Pteroxylon utile.	Sneeze Wood.	5,000
42	Quercus pedunculata.	Oak.	1,000
43	Robinia pseudacacia.	Robinia.	600
44	Sophora Japonica.	Sophora.	40

TABLE: I

Extract from Annual Report of the Conservator of Foresters for 1884.

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The second and third measures required the planting of trees mostly raised in nurseries. This resulted in the rapid increase of forest nurseries in the Western, Eastern and, later, the Southern Cape.

Five forest rangers were employed under Lister on the Cape Flats by the end of 1882 whose duties included "the collection of seed of Forest Trees and the propagation of young trees in nursery rows".

Lister wanted to start a nursery, like the one at Worcester fuel plantation, to raise forest trees on a large scale in the Cape division and in 1883 he selected, "a piece of ground about two acres in extent, above Tokai, at the junction of two streams", which he developed rapidly as a nursery. By the end of the year it contained 125,690 plants of forty-four different species. (Table I).

Mr. D.E. Hutchins was appointed Conservator of Forests, King Williamstown, in charge of the Eastern Cape, in 1883. Hutchins received his forestry training at the well-known French forestry school at Nancy and had had ten years in the Indian Forest Service before coming to the Cape. He was strongly in favour of afforestation and immediately started nurseries and plantations. He reported that by 1884 six nurseries (each of two acres or more) had been started at the Quacca, Kologha, Isidenge, Pirie, Kata and Amatola forests, and that each one raised 40,000 plants annually most of which were oaks, gums and pines, but the more valuable indigenous species were also included.

The Tokai nursery had been, according to Lister, appreciably enlarged in 1884 to cover seven acres. It held twelve thousand boxes, each containing twenty-five plants, and including those in beds, there were nearly one million trees of various kinds.

The next nursery of any size to be opened in the

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Western Cape Division was near Wolseley, where, in 1884, Lister was "successful in securing the lease of an erf, with buildings thereon, called Kluitjieskraal situated in the midst of crown land". The buildings could accommodate eighty convicts and the necessary officials and the entire area of the Kluitjieskraal forest reserve 2,159 acres (about 1000 morgen) was to be planted by convict labour.

A fourth nursery, on Table mountain, brought the number of plants raised annually in the Western Province to well over a million by 1887, while in the Eastern Province thirteen nurseries started by Hutchins, produced one and a half million plants.

The first large forest nursery in the George-Knysna Cape Midlands area, established at Concordia forest station, raised 156,816 plants in 1889. The George nursery was established in 1895 when "a start was made in raising seedlings of useful gums, pines and cypresses". Fort Cunynghame nursery in the Eastern Province began in 1894 and was enlarged to seven and a half acres by 1895.

The Cape Forest Department had 31 nurseries in 1900 capable of raising over two million plants annually. The actual returns for 1900 are recorded in the following schedule:

Forest Conservancy	No. of nurseries.	Plants raised 1900	No. of Spp. represented.
Western	9	1,931,233	303
Eastern	20	372,053	134
Midlands	2	69,058	54
Totals.	31	2,372,344*	

* Excludes plants on hand at beginning and end of year.

The Cape Forest Department at the end of the nineteenth century, in addition to maintaining and managing the remaining indigenous forests, was entrusted with two major tasks:

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1. To collect and test a large number of exotic trees for commercial afforestation at the Cape; and

2. To form state plantations on a large scale and as quickly as possible.

By 1900 the testing programme was well under way and trees and shrubs, both for commercial afforestation and ornamental purposes, had been collected for trial from all over the world. The nursery returns of this period are interesting, but lengthy, because they reflect the state policy, largely inspired by Hutchins, of testing many new species. The Tokai nursery return of 1900 for example included 303 species and 1,783,947 plants. This return is given in full in appendix 1.

Robertson (1926) has remarked as follows on the trials of species in the first quarter of the 20th century:

"Under Hutchins influence, much attention continued to be given to the selection and trial of climatically suited species, more especially, perhaps, in the new departments in the Transvaal and Orange Free State, and after Union, one of the first objects of the Research Branch established by the then Chief Conservator, Mr. J.S. Lister, in 1912, was to examine the results so far obtained and, generally to pursue the subject further". The main afforestation species for the various climatic regions of the country were selected and sufficiently tested by 1920 to indicate their suitability. With one or two exceptions the same species have been used for afforestation since then. The following schedule gives the main commercial afforestation species in use today.

Region.	Species.
Western Cape.	Pinus radiata, P.pinaster, P.canariensis, P.elliottii and Euc. cladocalyx.
Cape Midlands.	P.radiata, P. pinaster, P.elliottii, P.taeda, Euc. diversicolor and Euc.microcorys.

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Eastern Cape.	Pinus pinaster, P.radiata, P.canariensis, P.elliottii, P.patula, P.taeda, Euc.saligna, Euc.melliodora and Euc.sideroxylon.
Transkei.	P.patula, P.elliottii, P.caribaea*, Euc. saligna, Populus deltoides var. missouriensis and Acacia mearnsii.
Natal.	Pinus patula, P.elliottii, P.caribaea*, P.taeda, Euc.saligna, Euc.cloesiana, Acacia mearnsii and Populus deltoides var. missouriensis.
Zululand.	P.elliottii, P.patula, P.caribaea*, P.taeda, Euc.saligna, Euc.paniculata, Euc.maculata.
E.Transvaal.	Pinus patula, P.elliottii, P.taeda, P.roxburghii*, Euc.saligna, Euc.fastigata and Populus deltoides var. missouriensis.
N. Transvaal.	Pinus patula, P.elliottii, P.taeda, P.roxburghii*, Euc.saligna, Euc.cloesiana, Populus deltoides, var. missouriensis.
S. Transvaal and Orange Free State.	Pinus patula, P.elliottii, P.taeda, Euc. saligna, Euc.fastigata.

Planting of Pinus roxburghii*and Pinus caribaea*has been stopped because of defects in the wood of the available strains.

Forestry development extended beyond the borders of the Cape after the beginning of the twentieth century. In Natal and Transvaal, Forest Services began in 1902 and in the Orange River Colony in 1903. Officers from the Cape Department were chosen to head these new services! T.R. Sim became first Conservator, Natal; K.A. Carlson first Conservator, Orange River Colony and C.E. Legat, first Conservator, Transvaal, while J.S. Lister remained as Chief Conservator, Cape Province.

Upon Union in 1910, the four Forest departments amalgamated and Lister became the first Chief Conservator of Forests for the Union of South Africa.

EXPANSION OF NURSERIES FOR GOVERNMENT AFFORESTATION AFTER 1920.

Afforestation was seriously curtailed by the first World War (1914-18) and its immediate aftermath, and the demand for transplants did not increase until after 1920 when afforestation again expanded.

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Two major factors caused this expansion. Firstly, there had been an acute shortage of timber during the war period which had stressed the strategic importance of home-grown supplies and revealed the need for a dynamic afforestation programme to create this supply. Money for afforestation schemes, which had preciously come only from revenue funds, was consequently also allotted from loan funds. It was proposed to afforest 10,000 acres annually (Blue Book UG.21-19 published in 1919 and amended in 1922). Secondly, to offset the acute economic depression and considerable unemployment which arose towards the end of the war, the government decided to use the Forest Department in an unemployment relief scheme for Europeans.

This scheme enabled the Forest Department to extend afforestation during this critical period when funds were limited. White males were employed as labourers in the state forests and their families and dependents were housed in "settlements" on the forest reserves where they worked.

The first settlements were begun in July 1916 at Jonkersberg near George in the Cape Midlands and at Franschhoek near the village of La Motte in the Western Cape. By 1924/25 eight settlements to house white forest labour had been established. The policy of employing white labourers on forestry work was further implemented to relieve the serious unemployment during the economic depression of the early 1930's and by 1932/33 eighteen such settlements had been established in various parts of the country. At this time 1,367 white labourers were employed, and their families housed, under the scheme. These settlements remained part of the picture of South African forestry for a considerable time, and the last, Franschhoek, one of the original two, was finally closed in 1953/54.

The annual afforestation of 10,000 acres proposed in

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1922 was surpassed each year until the second great war (1939-45) diverted the country's funds and manpower into other channels.

The effect on the nurseries of the increased afforestation is illustrated by the histogram and graph of plants raised, (Fig. I and II) based on data given in appendix 2. During the five years, 1911-1915, over 44 million plants were raised for departmental use, but the following five years show a drop to 25 million, due primarily to the first World War.

The reviews of forest policy in 1919 and 1922 when it was proposed to plant 10,000 acres annually, is reflected by the doubling of the number of plants raised for departmental use during the period 1921/1925.

The rate of afforestation was appreciably increased from 1926 to 1930, when 72,435 acres were afforested, and during the depression period of the early 1930's. The afforestation rate of the Department of Forestry was increased primarily because of the Government's policy of using unemployed white labour for afforestation, and 83,535 acres, were afforested from 1931 to 1935.

The number of plants raised, for departmental use, during the first half of the 1930's, was, however, about eight million less than during the previous five years, because espacements were increased about the end of the 1920's from 5 x 5 ft. and less, to 6 x 6ft. for most conifers and to 8 x 8 ft. and even 12 x 12 ft. for the eucalypts.

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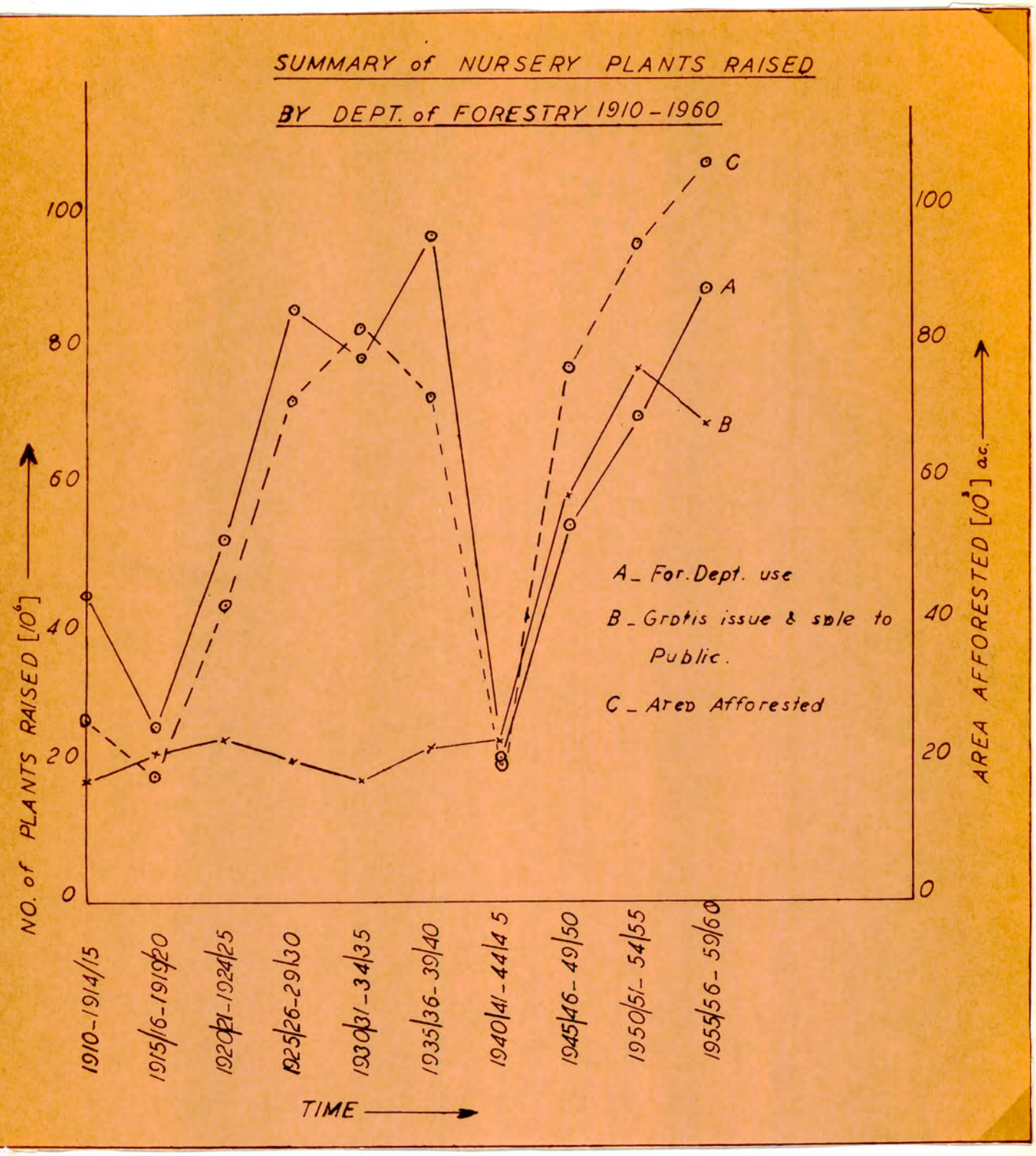

Fig. I.

Plants raised by the Department of Forestry for their own use and for sale to the public 1910-1960.

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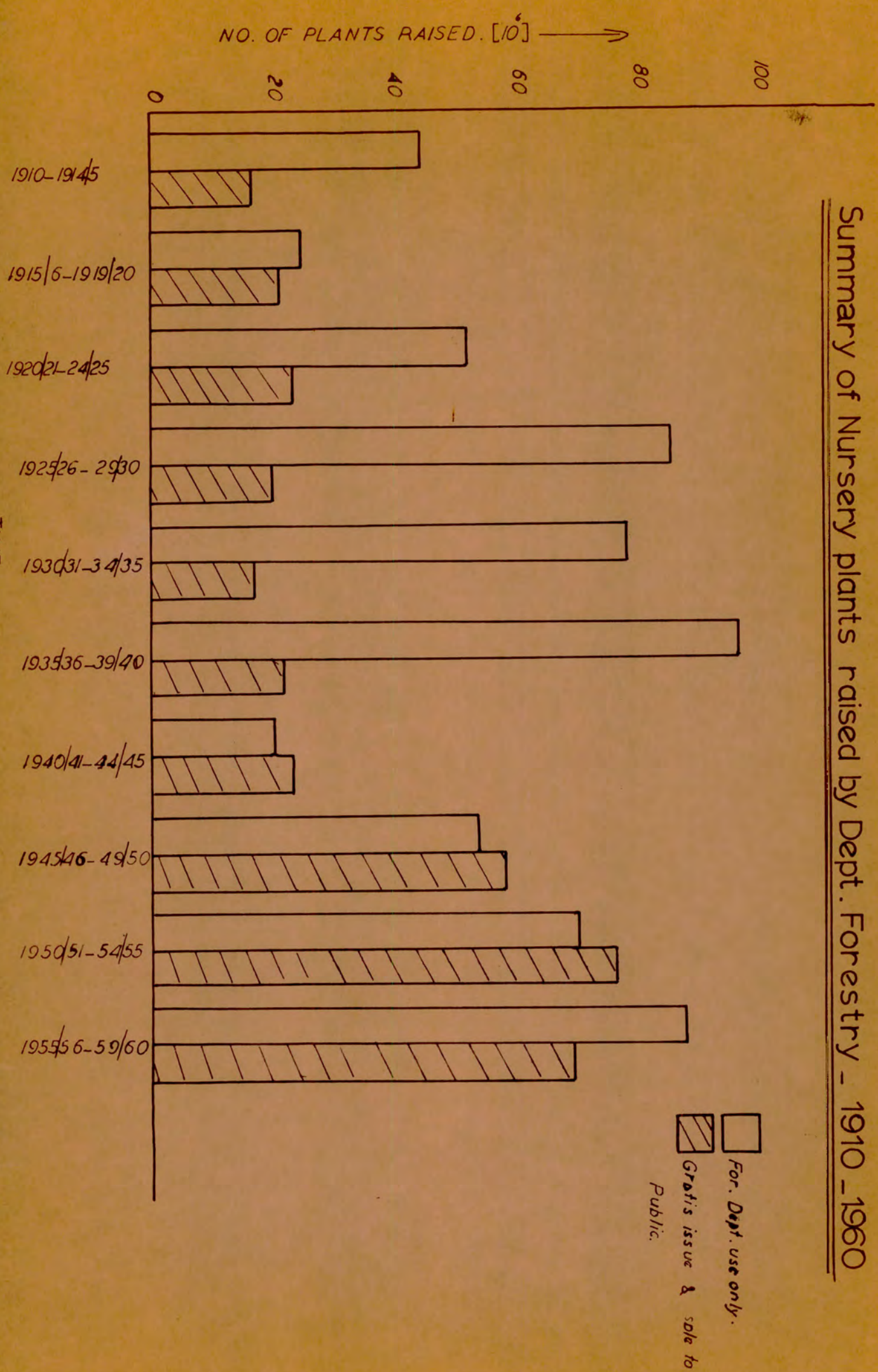

FIG. II. Histogram of plants raised by Department of Forestry for their own use and for sale to the public, 1910 to 1960.

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In the period 1936-40 the rate of afforestation dropped to approximately the same level as in the five years before 1930, i.e. 73,487 acres. The number of plants raised for departmental planting reached a peak, however, because of a marked decrease in direct sowing. The establishment of wattles and Pinus pinaster and occasionally other conifers, such as Pinus canariensis and Pinus roxburghii, by direct sowing had been adopted as standard practice in Western, Midland, Transkei and Eastern conservancies from about the beginning of the 1920's. This method of establishment became increasingly popular and reached its zenith during 1926-1930 when 28,663 acres were thus established. The technique was used during the period 1931-1935, 23,838 acres being sown, but it was discarded because species which could not be readily established in this way were favoured and because seed of the desired species was scarce. During the latter half of this decade just under 5,000 acres were established in this way. Even though the acreage afforested by the Department was over 10,000 acres during 1936-40, almost the whole of the 73,487 acres afforested was planted, using nursery raised plants. As planting espacements for most conifers were still relatively close (6' x 6') the forest nurseries had to produce many more plants and the record total of 96,363,224 was reached.

In 1939 a major change in silvicultural policy was adopted by the Department of Forestry and espacements of 9' x 9', and on poorest sites 12' x 12' , for all conifers species were adopted, except for pole production. The number of plants required for the afforestation of a given area was thus halved.

The second World War seriously affected the Union's afforestation programme only after 1940, but for the following four years funds and manpower, and consequently afforestation, were reduced to a minimum.

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The very appreciable part played by home-grown softwoods in the country's war effort (Timber output from S.A. resources rose by 266 per cent between 1937/38 and 1945/46, Bosman 1955), showed that the policy adopted in 1919 had been sound. In the annual report of the Department of Forestry for 1946/47, the following policy statement appeared: "in order to make the country self sufficient in softwood timber a target of 35,000 acres should be afforested annually for the next twenty-five years.

Between 1950 and 1952 the Forest Department acquired 90,068 morgen (190,144 acres) of Crown land on the Zululand Coast for afforestation. Afforestation of this area, at present by about 10,000 acres annually, has given rise to a considerable expansion of forest nurseries in this region.

During 1952 a large new central nursery was created at Vergoeding to raise about four million plants annually and a second large Departmental nursery was started in 1954/55 at Nyalazi for the Zululand afforestation. Each of these nurseries probably produces more plants than any other forest nursery South of the equator. The annual report of the forest Department of 1954/55 states that, "altogether twelve and a half million plants were raised in the Eshowe (Zululand) forestal district for departmental afforestation".

The annual afforestation target of 35,000 acres has never been reached, "due mainly to the acute shortage of staff" (Annual Report 1951/52). It rose steadily from 15,771 acres in 1947/48 to a record area of 26,775 acres in 1957/58. Since then the area afforested annually has dropped to 19,000 acres, but should the Department find it necessary to surpass the target figure, its nurseries as they exist at present, could produce the plants required.

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THE SUPPLY OF TRANSPLANTS BY THE GOVERNMENT TO THE PUBLIC.

From its inception the Forest Department of the Cape Colony sold plants from its nurseries to the public for commercial afforestation and for shade, shelter and ornamental planting.

Lister in his annual report for 1884 states that, "one of the chief functions of the Forest Department, however, is not only to form plantations on a large scale but to assist and encourage by judicious means private individuals and public bodies to plant trees." The number of plants sold and distributed gratis from the various nurseries of the Cape varied, but generally increased with the years. At Tokai in 1884, 43,235 plants were disposed of in this way, while in 1900, 215,824 plants, about five times as many,were taken by the public.

Afforestation by private individuals in South Africa has been and is encouraged by the example of the Forest Department, who showed that plantations of exotics could be profitable.

Private plantations are mentioned in the annual report of the Superintendent of Woods and Forests in 1890, who wrote: "Encouraged by the example of success which has attended plantations formed by the Forestry Department, private owners have extended planting to such a degree since 1884 that the Forest nurseries have distributed throughout the colony for planting on their properties from that period, close upon a million plants".

In 1910 a total of just over three million plants were sold or issued gratis from the nurseries of the Forest Department of The Union of South Africa. The annual number of plants distributed remained relatively constant until 1917/18 when it rose to 4½ million. It then remained at about this level until after 1930. The depression period of the early 1930's, during which state afforestation increased, caused the

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demand for plants from the public to decrease to about three million plants per year. In 1936/37 the level rose again and nearly 5 million plants were sold. This figure was maintained fairly constantly until the 1939/45 war after which there was a marked increase in the demand for plants.

The shortage of softwood timber and the high prices paid for home-grown timber throughout and immediately following the 1939/45 war, were incentives to the private land-owners to plant trees. More private land was afforested with pines during the fifteen years up to 1960 than during the previous forty-five years. The Department was caught unawares by this sudden increased demand and although it distributed over nine million plants in 1945/46, "orders for many thousands more were turned down due to inability to cope with them" (F.D. Annual Report 1945/46).

In 1947/48 a new scheme to encourage tree-planting was introduced. The object was to encourage farmers to plant trees for wind breaks and small farm woodlots on unused portions of their farms, and bona fide farmers were offered plants at the reduced rate of R2 per 1000. The ordinary price at this time was R6 per 1000 plants, and this consession led to an increase in sales of about 40 per cent, 10,660,000 plants being sold to the public in 1947/48.

Private afforestation, especially in Natal and the Cape Midlands, reached exceptional levels during the 1950's and more transplants were accordingly bought from the Department's nurseries. The supply was frequently inadequate. Nurseries were much improved and enlarged in 1952/53, but, the more plants the Department produced, the more the public required. 20,330,713 plants were distributed in 1953/54, yet the demand was still unsatisfied. Further improvements were then made to the nurseries and the Annual Report of the Department for 1953/54 reads: "At Elgin plantation in the Western Conservancy it was

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necessary to increase the size of the existing nursery in order to cope with the increased demand for plants by farmers"; "The number of plants sold to the public from nurseries in the Natal Conservancy increased by over 800,000 and in spite of enlargements to existing nurseries it was not possible to cope with the full demand. The new nursery at Empangeni was extended to raise a million plants whilst the Cedara nursery terraces were extended to accommodate approximately two million plants. The Dargle nursery was altered and enlarged and three million plants can now be raised at this centre. The new nursery at Vergoeding, established during the previous year, was enlarged and a second pump and engine were purchased to supplement the supply of water".

The cost of raising nursery plants rose steadily after the war (1939-1945) and the prices of transplants sold from Departmental nurseries were raised in 1954/55 to R4 (£2) a thousand for bona fide farmers and R8 a thousand at normal tariff. At the same time the regulations governing the supply of trees to bona fide farmers were tightened and the 12,5000 per farmer rule strictly observed. The immediate result of these changes was a decrease in sales of approximately six million plants.

Over 14½ million plants were sold annually for the next three years but in 1957/58 the number increased to over 17 million. This appears to have marked the peak of the present demand as the numbers have since been decreasing slowly. A complete list of plants sold and distributed gratis by the Forest Department for the period 1910 to 1959/60 is given in appendix 2.

THE DEVELOPMENT OF PRIVATE NURSERIES.

Private nurserymen have maintained that Government Departments of Forestry competed unfairly in the distribution of plants to the public. As early as 1884 Lister reported,

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"not withstanding much protestation from private seedsmen and gardeners surplus plants and seed of forest trees are yearly distributed throughout the colony from this forest division... as a rule the cost price is charged but in some cases they are given away gratis". (Lister, 1884).

Little is known about the development of private nurseries supplying forest trees in South Africa. Occasional statements appear in annual reports. Thus in 1890 Comte de Vasselot, discussing the growth of the Cape Department's sales to the public from 1884 to 1890, wrote: "Botanic gardens and private nurseries have doubtless supplied others in almost equal numbers".

A similar reference appears thirty years later in the annual report of the Union Forest Department for 1921/22, again without giving any concrete evidence! "The number of the latter (Departmental transplants disposed of to the public) again exceeded, 5,000,000, this number does not by any means represent the total private afforestation accomplished, for large quantities of transplants are sold by private nurserymen and raised by private tree planters themselves".

In 1926/27 there was a decrease of 103,000 in the sale of plants from the Department's nurseries in the Transvaal and Orange Free State Conservancies. The Conservator thought that this was "mainly due to the increasing competition by private and municipal nurseries, several of which advertised plants at half the Government's tariffs".

The private nursery industry appears to be in a vigorous condition at the present time. In 1959 representations to the Minister of Forestry were made by the nursery trade to prevent the Department of Forestry from competing in the sale and distribution of exotic,ornamental trees, shrubs and hedge plants.

The Minister agreed to curtail such sales by the

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Department and a policy statement was issued by the Secretary for Forestry to this effect. (Appendix 3) The State nurseries were grouped into three categories:

1. Nurseries situated within thickly populated white areas, competing directly with private nurseries.

2. Nurseries situated in or close to villages where there are no private nurseries.

3. Nurseries situated on forest reserves far away from towns or villages, serving large country districts with most of the sales through the mail.

All nurseries in category one were closed down. Most of these were of long standing such as the Retreat nursery near Cape Town which was established in 1912. Others were at Groenkloof (Pretoria), Bloemfontein and Port Elizabeth. Nurseries in category 2 continued to produce some exotic ornamentals but the public was advised that the Department would discontinue the production as soon as private enterprise could meet the demand. Examples of nurseries in this category are Elgin, Witfontein and Kruisfontein in the Cape, Dargle and Empangeni in Natal and Hangklip in the Transvaal. Nurseries in the third category, because of the wide area they served and the unlikelihood of competition arising, would continue more or less as before. Examples of nurseries in this class are Garcia, Kluitjieskraal, Witelsbos and Fort Cunyinghame in the Cape, Weza in Natal and Grenshoek, Wilgeboom and Belfast in the Transvaal. In all, 17 Departmental nurseries were closed and the field left free for private enterprise to develop.

The successful introduction and trial of exotic tree species for commercial timber production, shelter, shade, ornament, fodder, erosion control, sand dune reclamation, honey production and farm woodlots, and the subsidized distribution of transplants from Government nurseries have transformed the appearance of South Africa. Thus, the people have become tree-conscious, as they learnt to appreciate the usefulness and

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beauty of trees and saw the considerable national forestry industry develop.

Private plantations and saw-mills were originally modelled on those of the Government and, similarly, private forest nurseries have in recent years been modelled on Government nurseries. Forestry as a commercial enterprise originated in Lister's small nursery at Worcester in 1876. It developed to a mature and independent industry as the interest of the private investor was captured and extended in time from saw-milling to commercial afforestation and, eventually, to profitable forest nurseries.

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CHAPTER II.

THE CONSTITUTION AND SCOPE OF FOREST NURSERIES

The sale and distribution of transplants from nurseries is controlled by law. All nurseries selling plants must be registered annually with the Division of Plant Control and Quarantine of the Department of Agriculture in terms of Act No.42 of 1957 and they are inspected once or twice a year by officers of the Division. The object is to prevent or control the spread of insect pests, nematodes, bacterial and fungal diseases by applying quarantine where necessary.

The sale or movement of plants which are infected with any of the following diseases or pests is prohibited:

Diseases: Citrus canker; crown gall of any plant; bacterial blight of vines; virus diseases of any plant; bacterial diseases of fruit bearing trees and silver leaf of fruittrees.

Pests: Eelworm of fruit or nut-bearing trees; pustular oak scale; Araucaria scale or mealybug; wooly Aphis of apple trees and the following scale insects on any plant - pernicious, grey, round purple, sylvaticus, choff, white peach, long, burrowing, Spanish red, Ross, false round purple, Maskell's ebong, Massel purple; black thread and green soft scale.

The relevant portions of Act No.42 of 1957 are reproduced in appendix 4.

Nurseries in which plants are raised by the owners for planting on their own land need not be registered but no plants may be sold or otherwise disposed of from such nurseries.

REGISTERED NURSERIES.

A complete list of all registered nurseries in the Republic is published annually by the Division of Plant Control and Quarantine. For each nursery the name, registration number, the postal address and the type of stock raised are given.

(a) Department of Forestry. The registered nurseries of the Department of Forestry are permanent central nurseries producing trees for sale and for the

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Department's own use. The species are mostly for commercial afforestation, though some trees for windbreaks, shade and ornament are also grown. There are seventeen such nurseries covering an area of 56.8 acres. A list of these with addresses is given in appendix 5. During 1960/61 these nurseries produced about 8½ million plants of some 16 commercial forestry species (Table II).

Labour Supply. Most of the labour is brought in as required from the forest gangs, only a few labourers are retained full time in the nurseries. At some nurseries casual labour is employed to cope with seasonal work peaks, pricking out for example. Where possible cheaper labour, women and juveniles, are employed for lighter tasks. The nursery at Witfontein plantation near George employs white labourers who are physically handicapped and incapable of doing normal plantation work.

Because of the diverse labour policy and the varying rates of pay for the different races, it has been impossible to ascertain the number of people employed, or the wage bill they represent, directly. The number of labour units used is known, however, and the labour bill has been estimated. The total number of full-time and temporary units employed during 1960/61 was 36,424. Of these 27,848 (76.5%) were male and 8,476 (23.5%) female. Taking the average unit cost of one male unit as R1.00 and R0.50 for one female unit for all races, the estimated annual wage bill of the registered State nurseries is R32,136.

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(b) Private. According to the 1961/62 list of registered nurseries, one hundred and ninety-six nurseries, including municipal but not state nurseries, were raising trees. Circulars were sent to these to determine how many were producing transplants for afforestation on a commercial scale and eighty-one replies were received. Nineteen of those that reported were raising forestry species commercially; sixty-two did not raise forestry species, or produced too few to be of economic importance. Fourteen of the nineteen nurseries are in Natal, four in the Transvaal* and one in the Cape. A list of these nurseries and their addresses is given in appendix 6. Although only a 41 per cent return was received from this questionnaire it is assumed that all the private registered nurseries raising forest trees commercially have been recorded.

The reasons for this assumption are that:

1. No other nurseries were known to the Chief Regional Officers of the Department of Forestry or to the Secretary of the South African Timber Growers' Association;

2. a list of nurseries purchasing forest tree seed in commercial quantities from the Department of Forestry Seed Store contained no additional names; and

3. a questionnaire, sent to private timber growers, which requested all those who purchased their plants to return the name of the supplying nursery, yielded the names of three more nurseries, none of which were, however, registered, or normally sold trees.

It would appear therefore that there are twenty private registered nurseries raising forest trees commercially.

These nurseries produced just under 12 million plants during 1960/61 on an area of approximately 45 acres. Details of numbers by species are given in Table II.

* One additional nursery raising Eucalyptus grandis (E.saligna) in the Transvaal, has been reported by a forest officer.

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Labour supply. The total of labour units used by the private registered nurseries has been estimated from data supplied by sixteen of the nurseries. The average unit cost per 1000 plants, 3.5 units, is slightly lower than for the State nurseries, the female and juvenile units amount to 40 per cent of the total. Taking the average cost of a male unit to be one rand and that of a female unit to be 50 cents and if two juvenile units are taken as one female unit, the estimated annual wage bill for the private registered nurseries amounts to R34,000.

TABLE II. Plants raised for Commercial Afforestation by Registered Nurseries in South Africa (1960/61).

Species Pinus	Forest Department	%	Private	%	Total	%
P.canariensis	12,000		-		12,000	
P.elliottii	501,000		1,045,000		1,546,000	
P.montezumae	75,000		-		75,000	
P.patula	1,148,000		2,081,000		3,229,000	
P.pinaster	973,000		-		973,000	
P.radiata	3,743,000		284,000		4,027,000	
P.roxburghii	15,000		-		15,000	
P.taeda	25,000		-		25,000	
Total Conifers	6,492,000	(75.7)	3,410,000	(28.8)	9,902,000	(48.5)
%	(65.6)		(34.7)		(100.0)	
Euc. cladocalyx	196,000		7,000		203,000	
Euc.cloesiana	-		20,000		20,000	
Euc.diversicolor	77,000		-		77,000	
Euc.fastigata	210,000		-		210,000	
Euc.melliodora	85,000		-		85,000	
Euc.paniculata	2,000		-		2,000	
Euc.grandis (saligna)	1,380,000		8,089,000		9,469,000	
Euc.sideroxylon	66,000		-		66,000	
Populus deltoi-des.	70,000		319,000		389,000	
Total Broad Leafed.	2,086,000	(24.3)	8,435,000	(71.2)	10,521,000	(51.5)
%	(19.8)		(80.2)		(100.0)	
Grand Totals	8,578,000	(100.0)	11,845,000	(100.0)	20,423,000	(100.0)
%		(42.0)	(58.0)		(100.0)	

The registered nurseries of the country produce nearly equal proportions of coniferous and broadleafed stock for afforestation. The Forest Department nurseries, however,

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produce mostly conifers (75.7%) while the private nurseries produce mostly broadleafed species (71.2%). The number of species raised in Departmental nurseries for afforestation is appreciably greater (16) than in private nurseries (7). Eucalyptus grandis (Euc.saligna) is the major species in the private nurseries, amounting to 68 per cent of the plants raised. The only other species raised in any quantity are Pinus patula 18 per cent, and Pinus elliottii 9 per cent; four species make up the remaining 5 per cent.

In the Departmental nurseries the species of which most plants are sold is Pinus radiata, 44 per cent of the total, but many of these are used for plantings, such as shelterbelts, not primarily intended for timber production.

NON-REGISTERED NURSERIES.

Any concern may start a forest nursery without registering it, provided the plants are for its own use and are not sold.

The Forest Department and many private companies and individuals raise trees in such nurseries and an attempt has been made to gauge their size and importance.

(a) Department of Forestry. At present the Forest Department has 100 non-registered nurseries. While some of them are large permanent central nurseries supplying the plant requirements of several forest reserves, most are permanent local nurseries or temporary nurseries.

A permanent local nursery supplies the requirements of a single forest reserve, while a temporary nursery supplies a given area and is closed or moved when that area is afforested. Although temporary nurseries have advantages in the afforestation of outlying or inaccessable areas, permanent central

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nurseries are to be preferred where satisfactory rail or road transport facilities are available.

The Chief advantages of the larger permanent central nursery are: lower production costs; better qualified supervision; employment of well-trained labour, and greater use of mechanisation.

The non-registered nurseries of the Forest Department cover a total area of 104 acres and have an annual capacity of just over 25 million plants. The species raised are the same as in the registered state nurseries, but 86 per cent of the production are conifers, mostly P.elliottii (40%) and P.patula (33%).

(b) Private. When this study was commenced no comprehensive address list of the Republic's private timber growers existed. The largest available address list was that of the South African Timber Growers' Association with 392 members. A circular was therefore, sent to these members asking if they grew their own nursery stock, and if not, from whom they purchased it.

A recent survey by the Department of Forestry has produced a comprehensive address list of 1,446 private plantation owners, including municipalities.

One hundred and forty seven (147) returns were received from the circular sent to S.A.T.G.A. members, representing 37.5 per cent of the number sent out and 10 per cent of the total private timber growers in the Republic. 50 (34%) of the private growers raised their own plants for afforestation and re-afforestation; 70 (47.6%) purchased their plants from state (44%) or private (56%) registered nurseries; 27 (18.2%) were neither growing or buying plants, being wattle farmers or owners whose farms were

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fully planted and did not yet require re-afforestation.

The number of plants raised during 1960/61 by the 50 private growers from whom returns were received is given in Table III. While the number of returns is a very small proportion of the total 1,446 owners in the Republic, it seems likely, because of the very large number of plants raised (over 12½ million) that the majority of important private growers have been included.

TABLE III. Afforestation species raised in 50 Private Non-Registered Nurseries 1960/61

Coniferous Species	Number of plants	Broad-leafed Species	Number of plants
Pinus caribaea	211,000	Euc.cladocalyx	260,000
Pinus elliottii	1,171,000	Euc.cloesiana	69,000
Pinus patula	4,023,000	Euc.diversicolor	33,000
Pinus pinaster	47,000	Euc.fastigata	120,000
Pinus radiata	909,000	Euc.microcorys	7,000
Pinus taeda	310,000	Euc.paniculata	65,000
		Euc.saligna	5,373,000
		Populus deltoides var. missouriensis	19,000
Total	6,671,000 (53%)	Total	5,946,000 (47%)
		GRAND TOTAL	12,617,000

As the layout of a small nursery and the raising of a small number of plants is expensive and troublesome it seemed probable, even though the majority of growers were purchasing their plants, that there would be a correlation between plantation size and the number of growers raising their own plants. The 120 useable replies were therefore divided into plantation size classes, and the percentage raising their

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own plants, calculated for each class.

This data, shown graphically in figure III indicates a positive correlation between plantation size and the number of growers raising their own plants. With plantations of 1000 to 4999 acres at least 70 per cent of owners raise their own plants while above 5000 acres the percentage increases to 85 per cent.

The labour used in the country's non-registered nurseries is mostly diverted from other work whenever it is needed in the nursery. A reliable estimate of the labour used or the wage bill could not, therefore, be obtained.

ESTIMATED FUTURE REQUIREMENTS FOR PINE TRANSPLANTS.

The extent to which Eucalyptus species will in future be used in afforestation is so uncertain that an estimate of the demand for transplants to be expected has not been made but an estimate of the country's requirements for pine nursery stock has been made on the assumption:

1. that there will be no change in the present establishment techniques for afforestation or re-afforestation, and
2. that the present espacements will be maintained.

If these assumptions are valid, then an estimate based on two tables prepared by the Department of Forestry from a recent national census of South African plantations is possible. These tables are:

(1) Pine Clearfellings (Afkapxthinnings): Estimated areas for 5-yearly periods, 1960-2000. (appendix 7);

(2) planned Future Afforestation in acres. (appendix 8).

Table IV gives the country's requirements of pine plants/ per annum from 1960 to 2000, using an espacement of 9' x 9' and allowing 750 nursery plants to an acre, to include nursery losses and blanking.

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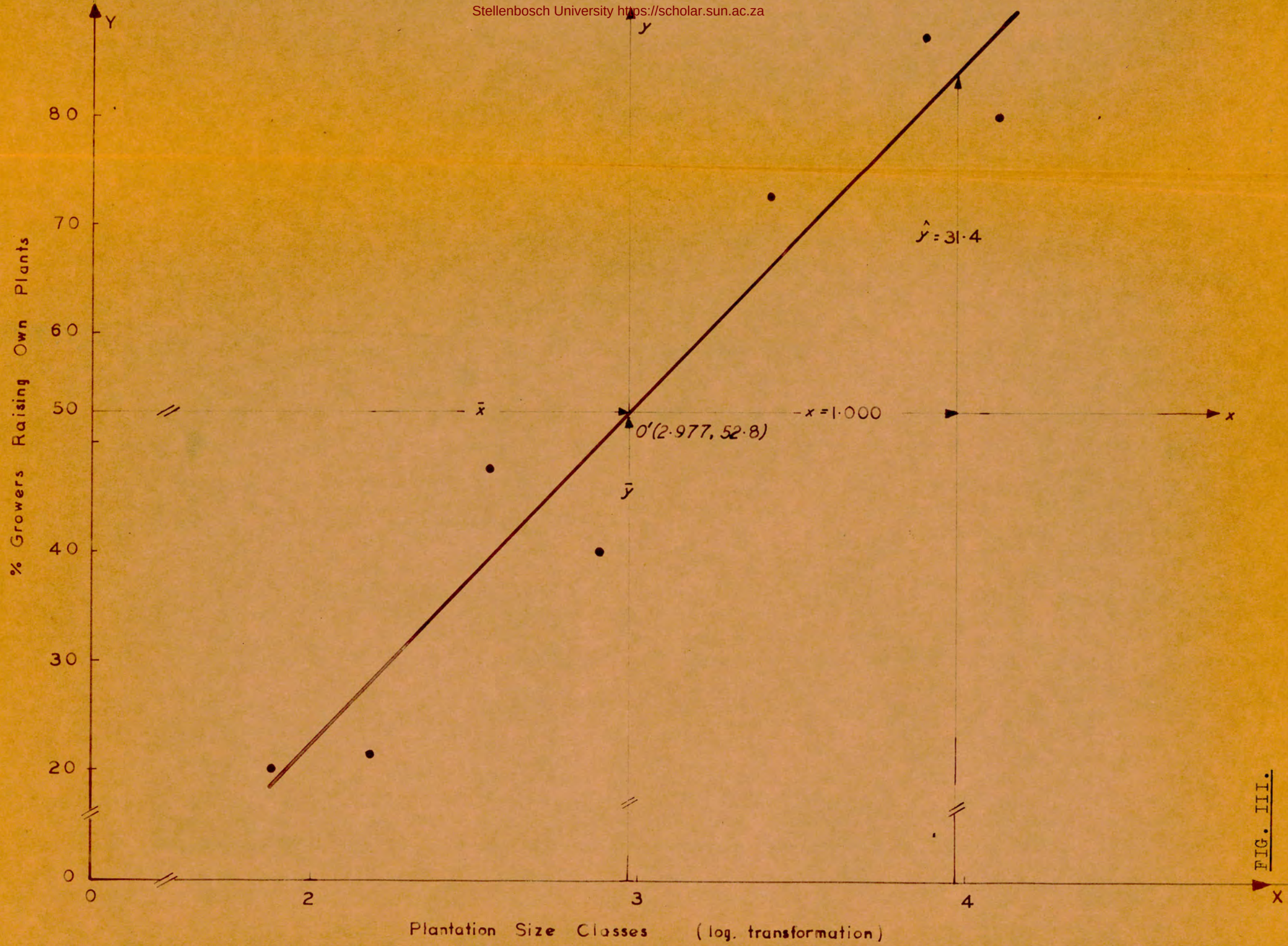

FIG. III.

FIG II. Sample Regression of % Growers Raising Own Plants on Plantation Size

TABLE IV.

PLANT REQUIREMENTS FOR CONIFEROUS AFFORESTATION AND RE-AFFORESTATION FOR THE REPUBLIC OF SOUTH AFRICA.

Period	New Afforestation (acres)	Re-afforestation (acres)	Annual requirements for 5-year period for all purposes.
1960/65	135,113	34,670	25,467,000
1965/70	119,486	62,264	27,263,000
1970/75	135,149	131,072	39,932,000
1975/80	-	158,267	23,740,000
1980/85	-	181,430	27,214,000
1985/90	-	162,274	24,341,000
1990/95	-	130,939	19,641,000
1995/2000	-	174,109	26,116,000

An immediate change in our present system of afforestation and replanting with nursery-raised stock seems unlikely. New plantations can be established artificially, either by direct sowings or by planting nursery-raised stock. At present, sowing is not favoured in the Republic because of the very high failures experienced, the patchy nature of the stocking and the longer fallow period before the site becomes fully productive. In recent years the author has undertaken research on direct sowing problems but final results are not yet available. Pre-sowing treatments to increase germinative energy, effective bird and rodent repellents to prevent loss of seed and the use of mulching techniques to ensure a higher survival rate are for example, being tested. It is possible therefore that direct sowing techniques may again be used in the future, though it is unlikely in the present decade. Most of the conifers at present planted in South Africa produce adequate seed for natural regeneration but it is unlikely that natural regeneration systems will be much used for some time because of the poor quality and form of the existing stands.

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This applies especially to Pinus pinaster and Pinus patula, both of which could easily be regenerated in this way.

A further point which is likely to tell against sowing methods, is the development of elite or superior seed of various species by the Department of Forestry's tree breeding section. This seed will be at a premium for some years to come and at least until the new seed orchards come into full bearing. It is unlikely that anything except nursery techniques will be used with such seed.

Changes in espacement are more difficult to forecast because they depend largely on the market for early thinning material. Thus during 1962 the planting espacement on first quality sites in Zululand which are close to pulp markets were decreased from 9' x 9' to 7' x 7'. The increase of 350 trees per acre appreciably improves the selection at the first thinning.

A decrease in espacement from 9' x 9' to 7' x 7' is unlikely to favour sowing establishment methods unduly even though the costs will increase by 65 per cent. Should it be desired to reduce espacements much below 7' x 7' for silvicultural reasons or to improve the quality of timber produced, e.g. to decrease the diameter of the young, poor quality, core wood, then economic necessity may require establishment by sowing methods. It is unlikely that this will come about in the near future, or indeed at all, until sowing techniques have been perfected.

It would appear, therefore, that the estimates for coniferous plant requirements can be taken as reliable at least up to 1975, though minor increases due to espacement changes on easily accessible first quality sites are possible. The figures should be taken as a rough guide, however, as appreciable changes in working plan prescriptions may become essential overnight because of fire or wind damage.

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The disastrous fire in the Midlands region in 1962 which will require the replanting of 10,250 acres in four years, not covered by prescriptions is an example of this type of occurrence. It is also realised that the basic data may be incorrect or biassed due to the manner in which they were acquired.

The general conclusion that the forest nursery industry is unlikely to expand in the future but is likely to enjoy a reasonably long stable period of constant demand, enabling it to maintain its present strength and prosperity, appears to be justified.

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CHAPTER III.

CURRENT NURSERY PRACTICE.

When plants were first raised in forest nurseries in South Africa, a cheap and admirably suitable container was available in which to raise them, namely, the four gallon paraffin tin, which cost two to three pence, and which, when split lengthways, gave two planting trays, capable of holding 25 to 30 plants each (Plate II).

British and European nurseries have used nursery beds from earliest times and relied upon frequent transplanting of the stock in the nursery to produce the fibrous root systems normally sought in planting material. The evenly distributed rainfall and absense of long dry periods at the time of planting in Britain and Europe are well suited to open-rooted planting and this method is universally used. Containers were retained for soft ornamental plantings but were not normally used in the forest nursery. It seems likely that experience in India led to the use of containers in nurseries. The drier areas of India, such as the Punjab, which have a relatively low and seasonal rainfall, and often experience warm dry periods shortly after planting, have been using containers for many years (Champion & Trevor ,1938).

Two of South Africa's first Forest Officers had experience with the Indian Forest Service before coming to the Cape. Lister for only a short time, but Hutchins, who made a name in the establishment of exotic plantations there, for ten years. Stebbings (1923) discussing the formation of plantations in India says: "although not actually originated by him the name of Mr. (later Sir) D.E. Hutchins will be for ever associated with this successful work. The first attempts

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Plate II. A view of portion of Tokai Nursery 1910.
All plants in tins.

(Photo F.D. Annual Report 1910).

to plant eucalyptus at Ootacamund (Madras) were made in 1843. The first government plantation was made by Hutchins in 1862".

Both men must have been familiar with the technique of raising plants in containers. Hutchins, while discussing various alternatives to augment the supply of paraffin tins, writes in the Cape Annual Report for 1886 "for similar work in India I have used cylindrical tiles".

The establishment of trees in India's less favourable climatic regions - fitfull summer rains, an almost tropical summer sun, and a long winter drought - required that the plants be given the most favourable start possible if they were to survive. With containers, disturbance of the roots of the plant is a minimum, each plant arrives at its permanent field position with a proportion of its root system still enclosed in soil, relatively undisturbed and active, and growth recommences quickly.

The tray method is at present employed over most of Southern Africa. Half paraffin tins were formerly used by the Government for all species of Eucalypt and most pines - Pinus pinaster and Pinus pinea were raised by in situ sowing. Although tins were cheap, there were too few available and in 1886 the Conservator of Forests, Eastern division, wrote in his annual report: "With the rapid extension of the forest nurseries an unexpected difficulty has arisen - the providing of planting pots or pans. All the old tins which could be purchased at three pence each have been bought from agents in East London, King Williamstown and Queenstown. These have been supplemented by purchase of coke tin and flat roofing iron".

Tins seem always to have been scarce and during the period 1890 to 1900 the nursery returns of Western and Eastern divisions record an appreciable number of plants in open beds. A typical example is found in the return for 1897 for the Table Mountain Nursery:

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NURSERY RETURN TABLE MOUNTAIN NURSERY: 1897.

	Species.	Number.
1.	**Plants in Seed beds.**	
	Fraxinus americana	2,000
	Fraxinus excelsior	30,000
	Fraxinus ornus	2,000
	Pinus sylvestris	40,000
	Pinus strobus	3,000
	Pinus ponderosa	3,500
	Ailanthus glandulosa	2,000
	Acacia melanoxylon	25,000
2.	**Plants in nursery beds.**	
	Quercus cerris	25,000
3.	**Seedlings in tins to be pricked out.**	
	Eucalyptus (7 species).	18,825
4.	**Plants pricked out into tins.**	
	Acacia melanoxylon	1,100
	Eucalyptus calophylla	575
	Eucalyptus obliqua	3,600
	Eucalyptus diversicolor	150
5.	**Plants pricked out into beds.**	
	Pinus pinaster	2,160
	Pinus insignis	3,700
	Pinus rigida	3,540
	Eucalyptus longifolia	5,650
	TOTAL	171,800

All broad-leafed deciduous species were grown in beds and planted out, open-rooted, when they were dormant. Very little information is available on the methods used to plant out the conifer stock raised in beds during this period. It seems likely, however, that these were also open-rooted when planted, as Lister in his pamphlet on tree planting in 1884 states: "When young trees are received from the nursery, their roots should at once be placed in mud, in a shady spot, until they are planted".

Hutchins in a pamphlet on tree planting (1893) says on page 7: "Bed plants succeed well in the Cape Peninsula, almost everywhere else in South Africa the hot winds render tin plants necessary". And again on page 9: "Open rooted

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planting is the cheapest but can only be practised with evergreens when the winter rains are steady and certain, as in the Cape Peninsula".

Henkel (1894) describes the method of lifting bed plants which do not retain balls of earth, "as is often the case with those which have not been pricked out in tins, boxes or nursery rows, the best way is to lift them carefully with all roots and rootlets and dip them (the roots only) in a thick mud mixed with cow dung, this will prevent the roots and rootlets from drying out".

Trials with open-rooted coniferous plants were made in the early 1890's and results varied from total failure to complete success. In his Annual Report for 1891 the Conservator Midlands reported that, "some three foot high plants of Eucalyptus marginata (Jarrah) sent up open rooted to a burnt area of the forest, from Concordia Nursery, succeeded with less than 5% loss. He also reported, "uniform losses from open rooted pine transplants at other plantations". Excellent results with open-rooted Pinus pinaster seedlings were obtained in 1893 at Tokai: "74,750 seedlings of Cluster Pine, taken straight from the nursery beds, were planted out over twenty one acres in the same manner as nursery transplants, three seedlings, however, being put into each patch as a precaution against failure. The event, however, showed that this precaution was unnecessary. The seedlings grew very whit as well as transplants. The success of these in situ seedlings has been so great that the system will probably now become permanent in Western Plantations".

Not withstanding this prophecy the raising of plants in beds became less popular and by 1910 nearly all evergreen broad-leafed and coniferous plants were raised in tins. Legat (1910) in a publication entitled "The Propogation of Trees from Seeds" wrote: "In this country experience has

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shown that by far the best results are obtained by raising seedlings and transplants of all evergreen trees such as pines, cypresses etc. in tins and boxes. It has been found that seedlings from boxes prick out much better than from open ground, and that transplanting evergreen trees from nursery lines gives a much higher percentage failure than from transplant boxes".

Planting from tins was, however, expensive and for inaccessible or mountainous country the plants were still occasionally lifted from the tins and planted open-rooted. An example is quoted from the Annual Report of the Chief Conservator of Forests (1910): "Instead of the usual expensive method of transporting tins of transplants long distances, the open-rooted method of planting was resorted to at Tokai plantation with success. The plants were taken out of the tins at the nursery, the roots dipped in a mixture of cow dung and mud, and covered with moist leaves and then carried up the mountain and immediately planted out. Where the climate is equable this method of planting can safely be adopted on cool moist days".

Nursery practice was not much changed between Union and the end of the first World War. If anything, the tray method became more entrenched and variations from it infrequent. Paraffin tins, which had been plentiful for some time, however, became scarce and expensive during the war years. The increase in price led to the use of wooden nursery trays which had seldom been used before. The tray was initially manufactured of sawn wattle wood and had the same dimensions as the half paraffin tin. As both containers were in use simultaneously, this was necessary for easy handling in the nursery.

Wooden trays were introduced as a temporary economic expedient owing to the high cost of paraffin tins, which was at that time up to eleven pence per tin. They were satisfactory,

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but it was expected that they would not be used when the price of paraffin tins again fell to three or four pence a tin. This proved partially correct and during the 1920's and early 1930's tin and wooden trays were used about equally. By the end of the 1930's,however, the wooden trays were used appreciably more than tins, and by the 1950's the tins had completely disappeared from the forest nurseries.

The shortage and higher cost of tins were the main reasons for discarding them but in 1938 the State began milling its own timber and boxwood was supplied to the nurseries as a gratis issue for the manufacture of nursery trays. This also assisted in the eclipse of the paraffin tin.

THE TRAY METHOD.

The tray method is today the same as that introduced at the end of the nineteenth century. Its main advantages are:

1. Plants can be safely transported over considerable distances without damage.

2. Disturbance of the plant is confined to a few minutes when it is removed from the tray and placed in the planting hole. Its roots are never exposed to the air.

3. Because the disturbance is kept to a minimum, survival is good and there is no appreciable check in growth, such as occurs with open-rooted planting stock.

4. Planting can be done at times of the year which would otherwise be unfavourable. Indeed with a favourable climate, such as is experienced in the Cape Midlands, it can be done at any time when the soil is moist.

The main steps in raising plants using the tray method are:-

Seed is sown in trays, occasionally in beds, at a density of about 400 to 600 seedlings per square foot. The seeds germinate and grow until they are a suitable size to prick out into the planting trays. The size required varies with the geographical locality of the nursery, time of year seed is sown and species. For example, Pinus radiata sown

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at Elgin in the Cape Province during April will be ready to prick out about six to eight weeks after sowing and will then be about three to five inches in length, or one to two inches above ground and two to three inches below. The same species sown in November, if not attacked by damping-off fungi, would attain a similar size and be ready for pricking out in three to four weeks. When the plants reach a suitable size they are lifted, the primary root lightly pruned, and replanted into prepared boxes at thirty plants per box. Here they remain until a height of about six to eight inches is attained. Generally this takes from ten to twelve months for pines but often as little as four months for some eucalypts. The standard nursery tray in this country is manufactured from locally grown pine timber and is 13½ x 9 x 4 inches, and weighs about twenty five pounds, complete with plants ready for planting. It is transported from the nursery to the planting site by lorry and carried by the individual planter during the planting operation. Plants are removed from the tray and planted into prepared pits with a sharpened trowel. A percentage survival of 80 per cent to 90 per cent can normally be expected and higher percentages are frequent.

This method has been used in South Africa since the first forest nursery began raising plants in 1875, and is still used by the majority of nurseries throughout the Republic of South Africa for coniferous and eucalyptus plants. Its success is indicated by its continuing popularity despite considerable increase in tray prices. Kenya and Southern Rhodesia, the two other countries of Southern Africa which have undertaken large scale afforestation with exotic species, have adopted the South African tray method, though the tray used is usually larger, 16" x 16", holding 49 plants. This size was chosen to give the most economical wood to plant ratio. The tray

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is light enough to be carried as a head load by the native labourers (FAO, 1958).

Private growers occasionally sow direct into trays at a density of about 50 seeds per tray. Generally the plants are reduced to 30 per tray at about two months but some growers prefer to leave the plants as sown to produce more small plants per tray. Costs are thus somewhat reduced and the period in the nursery frequently shortened as pricking out and the growth check caused by it are avoided.

The plants are often uneven and unreliably distributed in the tray, however, and for this reason, the variation is used only by private growers raising plants for their own use.

THE COMBINED BED AND TRAY METHOD.

A combined bed and tray method has been developed in Swaziland and is generally known as the Swaziland method. It was first developed in 1949 by Mr. R.P. Stephens for use in the extensive afforestation programme undertaken by Peak Timbers Ltd., in Swaziland (Long 1963). The object was to increase the life of the wooden tray which at that time was hard to obtain and very expensive to import into Swaziland. The method was also adopted, after some modifications, by the Usutu Pulp Company of the Colonial Development Corporation. Both companies maintain several nurseries, using the Swaziland method, capable between them of raising approximately eight million transplants annually.

The method as applied by the Usutu Pulp Company is to sow the seed thickly into beds and when the seedlings are of suitable size, they are pricked out into transplant beds. For planting, the beds containing the seedlings are divided into blocks or sods the size of a standard nursery tray and each block is placed in a tray. The plants are watered and left in the trays for a week to ten days before being planted

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out in the field from the trays. Planting is done in the same way as in the traditional tray method.

The method avoids the exposure and wear and tear of the trays during the period the plants are in the nursery and consequently they last longer. Creosote-dipped boxes are thus expected to last for at least three planting seasons.

The transplant beds are three foot wide, and four inches deep. The bed length varies from nursery to nursery depending upon the terrain and the needs of the forester. Each bed is edged by individual cement blocks which keep the light soil in position. Seedlings are pricked out at an espacement of 1½" x 1½" and are root-pruned regularly by using a special technique.

The essence of this method is the root pruning technique which was developed for it. Pruning is done by means of a 20 gauge piano wire which is pulled under the bed, to cut the roots, by means of a small hand powered winch. When the wire sticks or drags with the accumulation of roots one of the concrete side bricks is removed, the wire is pulled sideways from the bed, cleaned, and pulled back into position. Root pruning is essential to the method as the plants must produce roots within the four inches of the bed and not in the subsoil. Regular root pruning produces a plant with a good root shoot ratio, not so much by increasing the growth of the root as by decreasing the growth of the shoot. The form of the root is appreciably affected by the constant pruning, and becomes fine and fibrous and ideally suited for planting. Root pruning is first done about six weeks to two months after pricking out and is repeated about once a month thereafter depending upon the growing conditions. Longer periods may suffice in winter when growth nearly stops, while fortnightly pruning is often required at the peak of the early summer growth.

The percentage survival is similar to that of the

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traditional tray method i.e. 80 to 90 per cent average, with higher percentages under favourable circumstances. The method has the advantages of faster and improved growth after planting out over an open bed method, the reliability of the tray method, and an increased life for the planting tray.

The Tilbury method developed in Rhodesia by Stubbings (1958) is basically the same as the Swaziland but the apparatus used for root pruning is different. Stubbings required large plants to withstand the vigorous weed growth in the moist warm period, which follows planting in Rhodesia. The normal tray plant was not large enought and even if thinned out, tray plants do not develop into good two-year plants. The root shoot ratio is low, and unless conditions are very favourable, percentage survival is poor, because the plants die of desiccation in the field before the root system is sufficiently developed. By raising the plants in beds with a rooting depth of 5 to 6 inches and 2 inches between plants, and by regular root-pruning, Stubbings is able to produce a better balanced plant with a fibrous root system which is satisfactory. The large plants required remain appreciably longer in the nursery; about fifteen months for pines and twelve months for Eucalypts.

All pine species are sown directly in the nursery beds at the required espacement of 2 x 2 inches. A sowing template with nails 2 inches apart is used to mark the sowing positions in the bed. Two seeds are occasionally sown in alternate holes and the surplus plants pricked out into blank spots, or discarded if not required. Fine seeded species such as the eucalypts are sown broadcast and pricked out in the normal manner into prepared beds. When the plants are the required size - about 15 to 20 inches, the beds are cut into blocks and these are placed in trays for transportation to the planting site as in Swaziland. The Tilbury tray is, however, somewhat larger and deeper and has only three sides. It holds 40 plants, at

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2 x 2 inches espacement - five rows by eight. Planting is done in the usual manner.

The root-pruning apparatus (Plate III) consists of a frame of 1 inch galvanised iron piping with the pruning wire of twenty gauge spring-steel cable kept taut by a butterfly nut adjustment. It is drawn through the bed by four labourers, two holding the apparatus down and two pulling it along.

The Combined Bed and Tray Method, or the Tilbury variation of it, is used by several large private companies in the Republic and by other growers who raise plants for their own use. The South African Forest Investments and Twello Forestry Corporation, for example use the Tilbury variation.

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Plate III. The Tilbury Root Pruning frame used by the Twello Forestry Corporation, Barberton.

(Photo: C.L. Wicht).

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THE OPEN-ROOTED METHOD.

The method of using plants raised in beds and planted out without any soil around the roots is basically the standard method used in all temperate nurseries from Great Britain to New Zealand. When initially tried at the Cape results were very variable and largely dependent upon the vagaries of the weather following planting. The method fell into disuse, but with improved nursery techniques a more suitable open-rooted plant can be raised and the method is being satisfactorily used by the Cape Town City Council in their nurseries and plantations at Newlands, Steenbras and Silvermine, and by Thesen and Company Ltd., of Knysna. Seed is sown thickly in beds and pricked out into transplant beds, when of suitable size, or is sown direct at the desired espacement. The beds in the City Council nurseries are revetted and no further root pruning, other than a pricking out, is done. In Thesen's nurseries the beds are contained by wooden planking, the seed is sown in situ and the roots pruned regularly with piano wire.

On lifting, plants are root pruned, removed from the beds, the roots shaken free of soil, and tied in bundles of convenient size, generally about 100 plants. A further pruning of lateral roots is usually required after lifting. This is done by cutting the laterals of the bundled plants to approximately 6" with a sharp knife. When bundled, plants are generally wrapped in wet sacking for transport to the planting site.

SINGLE PLANT METHODS.

The three methods which have been described are those predominately used in large scale afforestation in South Africa. Single plant methods are used on a limited scale, however, in several countries outside the Republic. The use of individual containers for the production of nursery stock for commercial afforestation has been widely adopted in tropical and sub-

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tropical countries where climatic conditions are extreme. The method is satisfactory, but except under special local conditions is seldom economical for large scale production of nursery stock. A wide variety of materials have been used for containers. Natural materials including sown banana leaves, sections of bamboo, as used in the Congo, and a mud and straw brick as used in the Portugese provinces of Mocambique and Angola. Fabricated materials vary widely and include such diverse materials as wood pulp, tar lined craft paper, roofing felt, wood shavings, concrete and polythene. (FAO. Equipment Notes A.153, A.3.54, A.4.54, A.7.55). Polythene tubing and bags are being used in Southern Rhodesia but no other fabricated container has been tried on any scale.

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CHAPTER IV.

EXPERIMENTAL RESULTS.

The methods of afforestation using open-rooted plants and single plants in plastic bags have been examined experimentally. Most of the experiments were carried out at the Department of Forestry nurseries at Kruisfontein in the Cape Midlands, and Elgin and Franschhoek in the Western Cape.

THE OPEN-ROOTED METHOD.

The open-rooted method has two major disadvantages which limit the areas where it can be used. These are much greater reliance on favourable weather conditions for planting and survival than for other methods; and an appreciably longer growth check after planting than for other methods.

The method has never been used on any scale in the summer rainfall areas of the country, but has frequently been tried in the constant and winter rainfall areas which are more favourable to it.

The effects of different sowing methods in the nursery, of various protection treatments for the critical transfer period from the nursery to the field, and of different planting methods, have been investigated for the four pine species grown commercially in the constant and winter rainfall regions. The experimental data are given in appendices 10 to 15.

Of the commercial pines tested P.radiata, P.taeda and P.elliottii proved satisfactory for open-rooted planting (appendices 10 & 11). Pinus pinaster, however, was more susceptable to weather and seasonal changes than the other pines and open-rooted plants of this species gave significantly inferior results to tray plants (appendix 11). In one experiment on 12 acres (appendix 10) only 4.5 per centage survival was recorded.

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1. Sowing Experiments.

The pines were raised in framed beds, 3' x 12' with a depth of 4". The frames were constructed of 1" x 4" pine planking which had been pressure treated with creosote. The under side of the frames were planed to facilitate root pruning with piano wire.

In the initial experiments at Kruisfontein (appendix 10) direct placing of the seed at the required plant density was compared with the standard method of dense sowings followed by pricking out. In later work at Elgin (appendix 15) the standard method was compared with drill and broadcast sowings. In all experiments direct sowings gave higher plant percentages and better growth in the nursery. (See Tables V & VI).

TABLE V. (APPENDIX 10).

Plant Percentages of Pine Species: Direct Sown and Pricked Out.

Species	No. of seed per lb.	Direct Sown			Pricked Out.		
		Wt.of seed sown	No.of useable plants raised	Plant %	Wt. of seed sown	No.of useable plants raised	Plant %
P.radiata	18,000	6½ ozs.	5088	69	8 ozs.	4720	52
P.pinaster	10,000	11½ ozs.	6092	83	8 ozs.	1980	40
P.taeda	19,300	6 ozs.	4454	61	8 ozs.	5615	58

TABLE VI.(APPENDIX 15).

Plant Percentage of Pinus radiata raised by Broadcast sowing, drill sowing and Pricking Out.

Species	No.of Seed per lb.	Broadcast Sown	Drill Sown	Pricked Out
		Plant Percentage.		
P.radiata	16,500	38.8	50.1	22.8

The stock sown directly grew significantly better after planting in the field than that pricked out but percentage survival of only P.radiata was affected (See Table VII).

TABLE VII.

TABLE OF AVERAGE PLANT DIMENSIONS AND % SURVIVAL FOR PRICKED OUT AND DIRECT SOWN STOCK OF PINUS RADIATA.

Pricked Out			Direct Sown.		
Height inches	Collar diam.mm.	% Survival	Height inches	Collar dia.mm.	% Survival
6"	3.5	89.7	10"	6.5	95.9

There were no significant differences between the Root/Shoot ratios of pricked-out and direct-sown stock which was about .60 for both.

On lifting, plants were root pruned and soaked before removing from the beds. All soil was shaken from the roots and the plants counted into bundles. Lateral roots were too long and were trimmed to approximately 6" with a sharp knife after the plants had been lifted and shaken out. All damaged, undersized, and diseased plants were discarded.

2. Transit Experiments.

Four different pre-packing treatments and two different packing materials were tested using the stock raised by direct sowing and pricking out. The treatments were:-

(a) Control - no treatment

(b) Water dipping of roots

(c) Clay dipping of roots

(d) Plastic foliar coating of tops

The plastic foliar coating was applied before lifting, the other treatments after lifting. The packing materials were hessian sacks and polythene bags.

With two exceptions, the prepacking treatments did not differ significantly from the controls.

The plastic foliar coating significantly increased the percentage of the smaller pricked-out Pinus radiata by 12.8% (appendix 10).

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The coating used in this work is sold under the trade name of Goodrite Latex VL.600. South African distributors are Fisons Pest Control (S.A.) Ltd., Goordite Latex VL. 600 is supplied in concentrate and is diluted 1:4 with water. It is a milk white liquid which dries at room temperature to give a colourless film. It is applied as a spray.

Dipping the roots of P.taeda in clay increased the percentage survival by 5 per cent, compared with the control. (appendix 10).

The packing material used for the forty-eight hours the plants were in transit (appendix 10) had no significant effect on their percentage survival or initial growth.

In Great Britain open-rooted plants are normally heeled or trenched on delivery at the planting site. Plants are packed tightly in a narrow trench so that the roots and about one quarter of the shoots are below ground level. Soil is placed round the edge of the trench and is firmed down to prevent drying out.

Trenching was tested on the four pines grown commercially in the Cape Midlands i.e. Pinus radiata, Pinus pinaster, Pinus elliottii and Pinus taeda. Plants were lifted from boxes and shaken out to obtain open-rooted material, as bed-raised plants were not available. Differences in quality of box and bed-raised stock are not considered sufficient to change the conclusions drawn from this work. If anything bed-raised plants are better than box plants for open-rooted work and should give more favourable results.

All four pine species can be safely trenched, when dormant, for periods of up to seven days without significantly affecting percentage survival on planting. Trenching for up to three weeks did not reduce percentage

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survival of P.radiata, P.pinaster or P.taeda but appreciably reduced percentage survival of P.elliottii (appendix 12).

Increased root exposure of all four pines significantly increased the period of check before growth recommenced though for the periods tested, 20 and 40 minutes, percentage survival of P.radiata and P.pinaster was not directly affected. Percentage survival of P.taeda and P.elliottii, was significantly reduced by root exposure for forty minutes (appendix 12).

3. Planting Experiments.

Two experiments to compare open-rooted plants raised in beds with tray plants have been carried out. On a southern aspect, all plants were planted into prepared pits using trowels (appendix 14). On a northern aspect, the open-rooted plants were planted without prior pitting using spades (appendix 13).

Three and a half years after planting no significant differences in percentage survival or height growth existed between the open-rooted and box plants on the southern aspect, (appendix 14).

Open-rooted stock, spade-planted, without prior pitting, on the northern aspect, required blanking (21.5% failure) and suffered a check of four to five months before growth recommenced. Tray stock on this site planted into prepared pits required no blanking and height growth was only briefly checked (appendix 13). After a period of six years, however, no differences between the open-rooted and tray stock were noticeable. Canopy was closed throughout and the whole compartment appeared uniform. Temporary sample plots in the two stands gave the following data:

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	Normal planting Box plants into prepared pits.	Open-rooted stock, spade planted, without pitting.
Stocking per acre	460	450
Mean Height of Stand	38'	38'
Mean D.B.H. Stand	4.9"	5.3"

In another experiment at Farleigh Forest Reserve in the Cape Midlands open-rooted stock of P.elliottii and P.pinaster was compared with tray stock using three different planting methods:- (appendix 11).

(a) Trowel planting in prepared pits.

(b) Trowel planting without prior pitting.

(c) Spade planting without prior pitting.

Pitting significantly increased the percentage survival of the open-rooted stock and of the tray stock of Pinus pinaster. Percentage survival of open-rooted stock of P.elliottii did not differ significantly from tray stock if planted into prepared pits.

Percentage survival of open-rooted P.pinaster was significantly inferior to tray plants regardless of the planting method used. Only the tray plants planted into prepared pits gave satisfactory results for this species. All other treatments required considerable blanking. (Appendix 11).

THE SINGLE PLANT METHOD.

Several areas of the Western Cape, but especially regions of the Wemmershoek, Zachariashoek and Franschhoek forest reserves are difficult to afforest. The soils are mainly sand, often of considerable depth, lying in the deep valleys of the Drakenstein mountains. Aspects are generally southerly or easterly. They become very warm and dry in mid-summer and plant losses are frequently so high as to necessitate replanting. Afforestation by the Cape Town City Council at Wemmershoek,

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with open-rooted P.radiata plants, has failed completely for several years in succession, while the Forest Department at Zachariashoek and Franschhoek, using tray P.radiata, have had to blank up to 80 per cent. The plants at these centres survived the planting and resumed growth, but were killed by the mid-summer drought. It was concluded that the plants had in had sufficient time to become adequately established and that if they were raised in individual containers survival would be greater. Root disturbance on planting and, consequently, the period before growth recommenced would be less and it was hoped that the longer growth period thus gained would enable the plants to survive the summer.

The use of individual containers for the production of nursery stock is not new and a wide variety of materials have been tried. Most containers, while satisfactory as far as growth and survival are concerned, are too expensive or difficult to obtain for large scale production of transplants.

Polythene bags appeared, however, to warrant serious attention.

When these were first considered (about 1955) for raising commercial nursery stock, they were too expensive to warrant their use. Since then,however, the increased use and greater production of polythene has appreciably reduced the price of the bags. 125 guage bags, 5" wide and 7" deep, can now be purchased for R1.25 a thousand with 14 x 1/8" drainage and aeration holes perforated in the bottom 3" of the bags.

In Rhodesia le Roux (1959) and in Katanga Delvaux (1959) have shown that most pine species can be grown successfully in polythene bags, but few data were available as to whether their use was economical.

It was decided to test P.radiata plants raised in polythene bags on these difficult afforestation sites and to compare costs with the standard method of raising plants in trays. (Cost data is given in Chapter V).

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The bags were filled with normal nursery soil and seedlings of P.radiata were pricked out into them during the latter half of September 1960. At the end of May 1961, after eight months in the nursery, the trees were planted.

Bags were planted intact, without removal or rupture from the root-ball. A similar area of P.radiata from trays was planted on adjoining land. These plants had been pricked out in August 1959 and had been in the nursery for a year and nine months. They were between eight and ten inches high. Stock pricked out into nursery boxes during July, and August 1960, were only 3½ inches high and were considered too small for these difficult sandy sites. The plastic bags plants were 6" in height at time of planting.

At the end of January 1962, eight months after planting, both groups were enumerated for percentage survival.

Five rows were selected at random in each group and the first seventy trees in each row taken as the row sample. The data were analysed for group comparison, applying a null hypothesis and testing the difference between the means by the "t" test.

	Polythene Bag Plants.					Tray Plants.				
Row	1	2	3	4	5	1	2	3	4	5
% Survival	75.7	80.0	81.4	71.4	75.7	54.3	44.3	34.3	32.9	44.3
Group Means.			76.85					42.02		
Difference between Means "t" value								34.82 4.063** (8df)		

The highly significant improvement in percentage survival through using plastic bags is thought to be due to the absence of shock on planting and also to the excellent condition of these trees grown with adequate space and no competition.

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During 1962 a smaller cheaper bag (4" x 5" at 93 cents per 1000) became available. These were also tested but it was found that the percentage survival of P.radiata raised in them did not differ significantly from the tray raised controls. An interesting feature of this last experiment was the almost complete survival of all treatments in a block which had been sited in a scoffled fire belt. The adjoining blocks which were covered with a grass vegetation had almost no survival at all, regardless of treatment. The water regime of these sites is obviously highly critical throughout the summer and it would appear that the complete removal of the competing ground vegetation may be sufficient to ensure survival of tray plants. Work on this hypothesis is under way.

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CHAPTER V.

THE NEED FOR RELIABLE NURSERY COSTS.

The costs of raising plants in a nursery, transporting them to the planting site and planting them, appreciably influence the financial success of forestry as a business undertaking.

All costs incurred in these initial operations must be charged against the plantation for the whole of the rotation at compound interest. The rate of interest charged varies with the object of management but for commercial afforestation the rate at which money can be borrowed on the open market is frequently adopted. This is 6½ per cent in South Africa at present.

The addition of compound interest makes the cost of nursery practice all important in forest economics. Every rand spent in the nursery becomes R6-62 at 6½ per cent compound interest over 30 years, R9-07 over 35 years and R12-40 over 40 years. Savings or expenses which would have very little importance if incurred at the end of the rotation can change the overall financial picture when compounded for thirty or more years.

The essentials of good nursery practice are to produce plants which consistently give satisfactory survival and subsequent growth, to produce enough of them at the required time, and to do so as economically as possible. The problem is therefore, firstly to produce satisfactory planting stock and secondly to produce it cheaply.

Satisfactory planting stock should survive after planting in sufficient numbers to make blanking unnecessary, and should recommence growth as quickly as possible. With the wide espacement at present in use a high percentage survival is

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required to give adequate selection at the first thinning and to ensure as early canopy closure as possible. Blanking is generally unnecessary if 500 or more trees per acre survive from a 9' x 9' planting, giving a percentage survival of at least 93 per cent.

To determine the cost of plants reliable records of work done and plants raised must be kept. Different countries have set about this task in different ways, or at least differ in the degree to which they separate the various nursery operations.

For example the United States Forest Service divides its costs into the following components (Wakeley 1954):-

Seedling production

Lifting and packing

Soil fertility maintenance

Building and equipment maintenance

Building and equipment depreciation

Local administration.

Seedlings transplanted in the nursery to give 1 + 1, or 1 + 2 transplants require an additional head, e.g. first year transplant production. Seedling production includes the cost of operations such as seedbed making, sowing, bird patrol, watering, mulch covering and removal, hand and mechanical weeding, protection and other treatments.

The cost accounting of the British Forestry Commission is somewhat more elaborate than the American as individual operations are recorded separately.

The following heads are used:-

Preparation of beds (sowing)

Preparation of lines (transplants)

Sowing - Conifers

Sowing - Hardwoods

Lining Out

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Lifting and grading seedlings

Lifting and grading transplants

Weeding seed beds

Weeding transplant lines

Protection

Fallow, green crops and manuring

Other.

Road works, building maintenance and local supervision are recorded separately. Plant records give the number of hardwood seedlings and transplants and the number of conifer seedlings and transplants raised and the cost per 1000 of each type can be computed.

In South Africa the Department of Forestry records all nursery expenditure, except seed cost, under one head, there being no subdivision into individual nursery operations. Seed collection or purchase is booked under a separate head.

This method of booking is adequate for determining the total cost of plants produced for afforestation and the profitability of a nursery selling to the public. The main drawback is that the efficiency or otherwise of individual operations cannot be checked. This type of information is completely lacking in the South African forest literature and so it was decided to try to obtain representative costing data for the different methods of raising plants in South African nurseries.

South African Nursery Costs.

A number of owners of large nurseries were asked for reliable costing data for the year 1960/61. The following is a list of the sources of information for tables VIII to XXII.

Tray Method.

1. The Department of Forestry from:
   (a) Efficiency Study No. 12 at a Transvaal nursery.
   (b) Elgin nursery in the Western Cape.
   (c) Empangeni nursery in Natal.

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2. South African Forest Investments (Pty.) Ltd., from their nursery at Hendriksdal in the Eastern Transvaal.

Combined Bed and Tray Method.

1. Peak Timbers Ltd., from Piggs Peak nursery, Swaziland.
2. S.A.F.I. from Ramanas nursery, Sabie, Transvaal.
3. Twello Forestry Corporation, Barberton, Transvaal.

Data was also supplied by the Tilbury Estate nursery, Melsetter, Rhodesia, but because of the appreciably longer nursery period required there, the data have been omitted.

Open-rooted Method.

1. Cape Town City Council from Steenbras nursery.
2. From experimental work done by me at the Department of Forestry nurseries at Elgin and Kruisfontein.

The costs of raising pines in plastic bags are from experimental work done by me at the Department of Forestry nurseries at Elgin and Franschhoek and from the Cape Town City Council nursery at Wemmershoek.

It has not been possible to obtain reliable or comparable data, except for the actual nursery operations. Overheads have been omitted. This means that the costs given are too low. By how much depends largely upon the size of the organisation and on the size and capacity of the nursery. For example a small nursery such as the Department of Forestry nursery at Empangeni, raising approximately 400,000 plants annually, will require a nursery foreman while another Departmental nursery such as Witfontein raising roughly one and a half million plants annually will require a nursery foreman and a head labourer so that the supervision costs per 1000 plants will be lower at the latter.

Where-ever possible unit and cash expenditures have been recorded separately, only in the final and comparison tables (Tables XVIII to XXII) have they been pooled.

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Labour costs vary appreciably in the Republic both with race and sex and for the comparison tables an arbitrary unit rate of one rand has been adopted throughout.

This has been done mainly for ease of computation but also because it is close to the actual wage for a male bantu labourer when cash and kind (rations and quarters) payments are included. It is appreciably lower than the rate paid to male coloured labourers by the Cape Town City Council.

In the case of the two major method, the Tray and Combined Bed and Tray methods, costs for the individual operations and more especially the percentages of the total nursery costs charged to the individual operations, should be a particularly useful guide to the forest nursery man in his operations, to show where the main costs lie and thus, where possible, to help to reduce them.

Tables Nos. VIII, IX, X, XI and XVIII give the costs supplied under the Tray Method; Tables XII, XIII and XIV and XIX give the costs supplied under the Combined Bed and Tray Method; Tables XV, XVI and XX give the cost of producing bed plants for open-rooted planting; Tables XVII and XXI give the costs of raising plants in plastic bags.

Table XXII gives a comparison of the mean costs obtained from seven nurseries for the two major production methods, and actual costs for raising experimental plants for the two minor methods.

Tables VIII to XVII are as accurate as the available data permit and can serve as a guide to the actual costs of the various nursery operations, but it must be stressed that they do not include overheads, such as supervision, maintenance and depreciation of equipment and buildings, or any permanent improvements to the nursery terrein. In tables XVIII to XXII the costs themselves are only of comparitive value, as a unit rate of one rand cannot be universally applied. The percentage

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figures should remain reliable, however, as changes in labour costs, will be relatively constant for each operation and for the whole.

Nursery costs vary from one nursery to another even when the nurseries use the same method of raising plants. In some cases a high cost on an item is explicable and due to circumstances outside the control of the nurseryman. For example the cost of soil transportation at Elgin nursery is appreciably greater than at the other three Tray Method nurseries given in the tables because the soil must be hauled 12 instead of 2 to 3 miles.

The differences in the costs of the methods and the way the costs are distributed is shown in Table XXII. The value of these tables is illustrated when the costs for the Combined Bed and Tray Method and open-rooted methods are compared. The costs agree fairly well but in the open-rooted method costs more than twice as much. Tables XII to XV show that the unit rate is about the same for each and so is the number of prunings. It was only after these tables had been prepared that the effect of the method of root-pruning on the cost of the open-rooted method was noticed. The wire had been drawn under the beds by hand, which gave satisfactory plants, but appreciably shortened the life of the pruning wire. By making a Tilbury pruning frame or adopting a Swaziland winch system, wire life could be prolonged and the costs reduced.

The very high percentage cost of the tray under the Tray Method stands out clearly, as does the high percentage cost of watering, weeding and root pruning.

The major costs under the different methods are:-

Tray Method - the tray price, watering, weeding and root pruning.

Combined Bed and Tray Method - Watering and weeding.

Open-rooted Method - Watering and weeding.

Plastic Bags- the filling and preparation of the bags.

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POSSIBLE METHODS OF REDUCING NURSERY COSTS.

The tray is the most expensive single item of the Tray Method and has probably recieved the least attention. The present method of tar-dipping increases costs without effectively increasing tray life. If a satisfacotry method could be found of increasing tray life the cost of the Tray Method could be considerably reduced. The cheapest method, which should be further investigated, is impregnation of wood with preservatives under pressure. Boxes at Thesen's nursery near Knysna, pressure treated with Tanalin before being nailed, lasted three seasons in the nursery and still appeared as strong and unharmed as in the first year. The cost of treating was equivalent to tar dipping (Roberts 1962). Tanalin may not be the best preservative for use on nursery boxes and others should be investigated.

A more resistant material, perhaps costing more, but lasting longer, might be more suitable than wood.

Metal has been used by the Twello Forestry Corporation but for the Combined Bed and Tray Method and the tray was thus in use for only a short period and protected from the elements for the rest of the year. The individual trays cost .53 rand each. Other materials which could perhaps withstand the wear and tear of a year's weathering without harm are fibre glass and Styrene plastics. These are expensive but they should last very long. Trials are needed to determine the economics of using these materials for trays.

A larger tray to give a higher plant per unit wood ratio would decrease tray costs. The most suitable size for a nursery tray appears to be 16" x 16" holding 49 (7 x 7) plants. This has an appreciably higher plant per unit wood ratio than the present size and is still sufficiently manageable to be handled by one man.

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Watering, weeding and root pruning costs at Elgin nursery during 1960/61 amounted to 36.7 per cent of all costs at this nursery. Costs for the individual items were recorded separately by the nursery foreman at my request. The percentages for the separate items are:-

Watering, 1440 units	64%	2240 units on 1,170,000 plants or 1.915 units/1000.
Weeding, 245 units	11%	
Root Pruning, 495 units	22%	
Bird guard, 60 units	3%	

Watering and weeding make up a very high proportion of the total costs at all nurseries whatever method of raising is used. At Elgin watering alone accounts for 64 per cent of the total costs under this head. The only other nurseries where separate watering figures were obtainable were from the Cape Town City Council nurseries at Steenbras and Wemmershoek.

The very high costs of watering and weeding at Steenbras are reflected in tables XVI and XX. This nursery is given in the tables to show the very high cost these operations can assume, it is not included in table XXII. Watering amounts to 50 per cent of the watering and weeding head at Steenbras.

Where watering costs are high the most effective method of reducing them is by the installation of an automatic sprinkler system. Two examples of the reduction in costs obtained following actual conversions are given in tables XXIII and XXIV. In the first case at the Cape Town City Council nursery at Wemmershoek a pumping unit as well as piping were necessary, while at the second, the S.A.F.I. nursery at Hendriksdal, a gravity feed was possible.

In both cases the systems paid for themselves in labour savings during the first year. In addition water distribution is more regular than can be attained by manual watering from cans (appendix 9).

For small nurseries where the number of plants is

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unlikely to be sufficient to warrant the layout of a sprinkler system another possible method of reducing watering costs is by mulching with plastic strips. Figure IV shows the effect of complete and strip black plastic mulch on evaporation from nursery boxes. Preliminary investigations on the effect of similar mulches on Pinus radiata plants shows that temperature side effects of the complete mulch are detrimental to the pines but that the strip mulch produces no unfavourable effects. Work on this line of investigation is proceeding.

The above are a few examples of the way in which nursery costings in the Republic can be reduced, either by changes in technique or by the adoption of mechanisation. Other aspects of nursery practise at present under investigation are:- the use of weedicides, fertilizer trials and different sowing and cultural techniques. All are capable of further reducing South African forest nursery costs, by reducing the labour bill, by decreasing the period the plants are in the nursery, or by increasing the plant percent.

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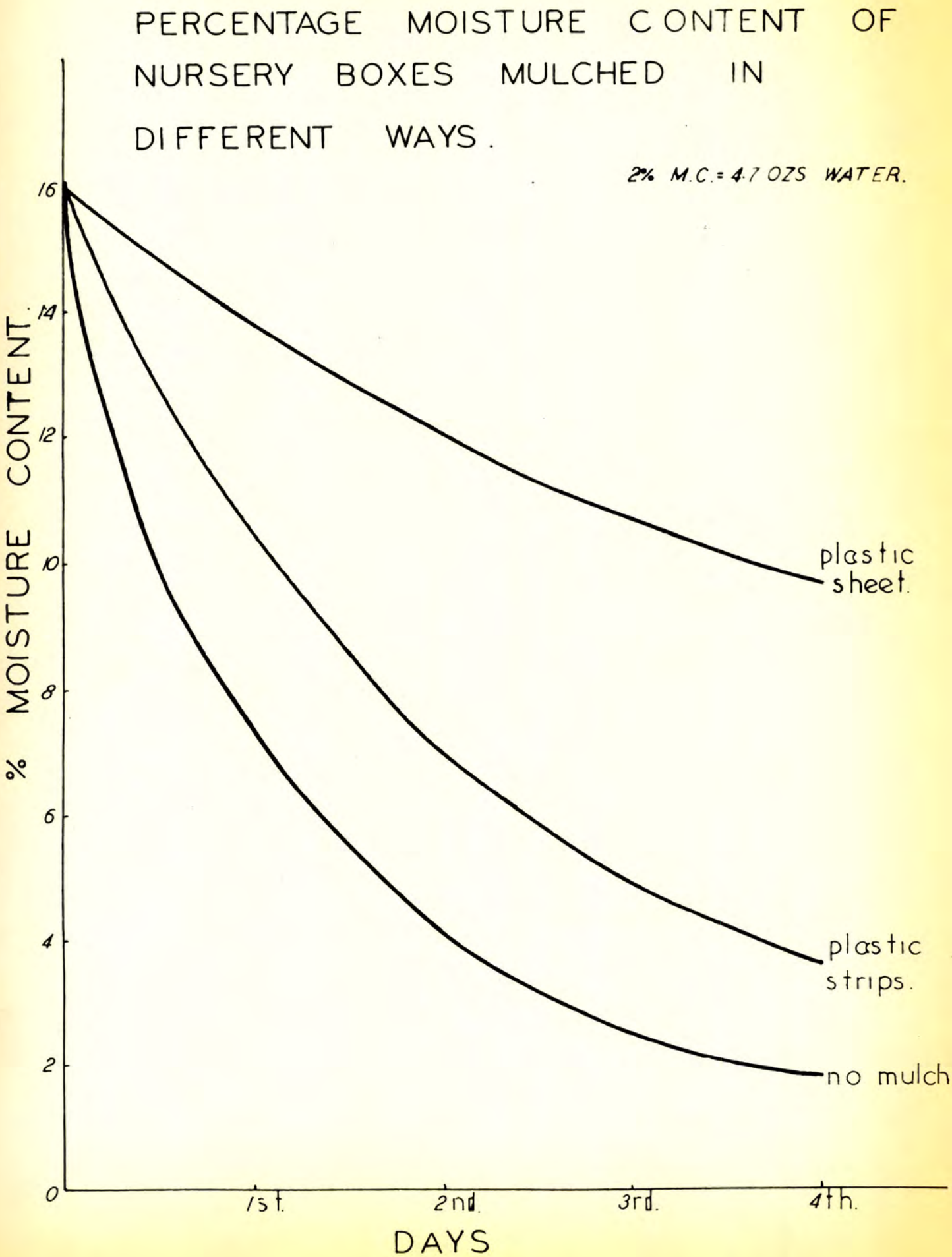

FIG. IV. Effect of Complete and partial black mulching on water losses from nursery trays.

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TABLE VIII.

Cost of Raising 1000 Pinus plants under the Tray Method. Figures taken from Forest Department. Efficiency Study No.12 dated 19.7.1961. "The raising of plants for afforestation". (Slightly amended).

		Units	Cash Rand
1.	Manufacture of Nursery trays: One labourer making 120/day. Unit cost of manufacture of 40 trays.	.333	
1(a)	Cost of material for 40 trays (wood and nails) at .087 rand per tray.		3.480
2.	Tarring of trays: Including making of fire, tarring and removing trays. One labourer tarring 1334 trays per day. Unit cost for 40 trays.	.030	
2(a)	Cost of tar for 40 trays, 1 drum being adequate for 1000 trays.		0.180
3.	Transport of Soil: A seven ton lorry, driver and eight labourers move ten loads/day - 140,000 lbs. sufficient for 5,600 trays (at 25 lbs/tray) or 620 trays/unit. Unit for 43 trays or 1000 useable plants.	.069	
3(a)	Transport cost on soils for 43 trays based on 13½ cents per mile for 7 ton truck and haulage distance of 2 miles.		.004
4.	Preparation and filling of trays for sowing and pricking out. One labourer can fill and remove 120 trays/day. Unit cost of filling 3 sowing and 40 pricking out trays.	.358	
5.	Sowing of seed: One labourer can sow 600 trays per day. Unit cost of sowing three trays.	.005	
5(a)	Cost of seed sufficient for 1000 transplants seed costs taken at Departmental tariff of R1.25 per lb.		.200
6.	Pricking out of seedlings: One labourer can prick out eighty (80) trays per day. Unit cost of pricking out 40 trays.	.500	
7.	Watering of plants, weeding, root pruning and general care of nursery. (Data not given) Unit cost per 1000 plants.	3.000	
	Total costs/1000 plants.	4.295	R3.864
	Total costs of 40 trays.	.363	R3.660

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TABLE IX.

Cost of Raising 1000 Pinus plants using the Tray Method.
Figures supplied by F.D. nursery: Elgin.

		Units.	Cash
1.	Manufacturing of trays: one labourer making 70 trays per day. Unit cost of manufacture of 40 trays.	.571	
1(a)	Cost of material for 40 trays (wood and nails) at .087 rand per tray for wood and nails.		3.470
2.	Tarring - This operation has been stopped at Elgin nursery.	-	
3.	Transport of soil: A three ton lorry, driver and four labourers move six loads/day - sufficient for 1800 trays (at 20 lbs/tray. Unit cost for 43 trays.	.119	
3(a)	Transport cost on 43 trays based on 11 cents per mile for 3 ton lorry and average haulage distance of 6.5 miles.		.034
4.	Preparation and filling trays: One labourer can fill and remove 234 trays/day. Unit cost of filling 3 sowing and 40 pricking out trays.	.184	
5.	Sowing of seed: One labourer can sow 600 trays per day. Unit cost of sowing 3 trays.	.005	
5(a)	Cost of Seed for 1000 Transplants: Seed cost taken at Departmental tariff of R1.25 per lb.		.200
6.	Pricking out of seedlings: One labourer can prick out 70 trays/day. Unit cost of 40 trays.	.571	
7.	Watering of plants, root pruning, weeding and general care of nursery. (2240 units for 1,160,000 plants) Unit cost per 1000 plants.	1.931	
	Total costs/1000 plants.	3.381	R3.704
	Total cost of 40 trays.	.571	R3.47

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TABLE X.

Cost of Raising 1000 Pinus plants using the Tray Method.
Figures supplied by F.D. nursery Empangeni.

		Units	Cash
1.	Manufacture of trays: One labourer making 66 trays per day. Unit cost of 40 trays.	.606	
1(a)	Cost of Material for 40 trays (wood and nails) at 9.4 cents per tray (includes railage).		3.76
2.	Tarring of trays: no data available.	.030*	0.18*
3.	Transport of soil: no data available.	.069*	.04*
4.	Preparation and filling of trays: One labourer can fill and remove 100 trays/day. Unit cost of filling 43 trays.	.430	
5.	Sowing: no data available.	.005*	.20*
5(a)	Cost of seed:		
6.	Pricking out of seedlings: One labourer can prick out 50 trays per day. Unit cost of pricking out 40 trays.	.800	
7.	Watering plants, root pruning, weeding and general care of nursery. 540 units required for 400,000 plants. Unit cost per 1000 plants.	1.350	
	Total Cost/1000 plants	3.290	4.18
	Cost of 40 trays.	.636	3.94

* F.D. Efficiency study rates used where original data not available.

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TABLE XI.

Cost of Raising 1000 Pinus plants under the Tray Method. Figures supplied by S.A. Forest Investments Ltd. , from their Hendriksdal Nursery.

		Units	Cash
1.	Manufacture of Nursery trays: One unit making 75 trays each 12" x 16", holding 35 useable plants. Unit cost/ 1000 plants or 29 trays.	.387	
1(a)	Cost of Material for 29 trays (wood and nails and tar) at 10 cents each.		2.900
2.	Cost of tar and labour required for tarring not available separately. Included in 1 above.	-	-
3.	Transport of Soil: 5 ton lorry, driver and 4 labourers move 8 loads/day. 80,000 lbs.- sufficient for 2760 trays at 29 lbs/tray or 552 trays/unit. Units required for 29 trays at 1000 useable plants.	.053	
3(a)	Transport cost on soil for 29 trays based on 13 cents per mile for a 5 ton lorry and haulage distance of 1½ miles.		.004
4.	Preparation and filling of trays for sowing and pricking out: No information available take F.D.O. & M. study rate of 120 per unit. Units required for filling 29 pricking out and 3 sowing trays.	.267	
5.	Sowing: No information available, take F.D.O. & M. study rate of 600 trays/ unit. Cost of sowing 3 trays.	.005	
5(a)	Cost of sufficient seed for 1000 transplants. Seed costs taken at Departmental tariff of R1.25 per lb.		.200
6.	Pricking out of seedlings: 75 trays or 3,000 plants per unit. Unit cost of 29 trays.	.387	
7.	Watering of plants, weeding, root pruning and general care of nursery. 1,012 units for 293,000 plants. Unit cost per 1000 plants.	3.454	
	Total Cost per 1000 plants.	4.553	R3.104
	Total Cost of trays for 1000 plants.	.387	R2.09

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TABLE XII.

Cost of Raising 1000 Pinus plants using the Combined Bed and Tray Method: Figures supplied by Peak Timbers: Piggs Peak, Swaziland.

		Units	Cash
1.	Manufacture of bed retaining bricks.1 unit makes 150/day. 138 required for 100 ft. bed. Containing 7,500 useable plants. 18.4 bricks per 1000 plants. Unit cost/1000 plants.	1.23	
1(a)	Cost of brick materials. Cement, 70 bricks per 94 lb. pocket costing .68 rand. ∴ Cost of 18.4 bricks or Cost/1000 plants.		.180
(b)	Loading and Transporting river sand for bricks using rate of 1: 8,(94 lbs. cement to 752 lbs. sand). Unit costs per 1000 plants.	.080	
(c)	Transport costs on 5 ton tip-truck 4 mile haul at 15 cents/mile. 200 lb. sand for bricks for 1000 plants. Cost/1000 plants.		.024
2.	Soil transportation: 5 ton tip-truck, driver and eight labourers excavate and deliver to nursery six loads per day. 60,000 lbs. sufficient for 9.6 100' x 30" beds, each containing 7,500 useable plants. Unit cost per 1000 plants.	.125	
2(a)	Cost of transport: Haulage distance of 4 miles at 15 cents per mile. 1 load sufficient for 1.6 beds or 12,000 plants. Cost per 1000 plants.		.100
3.	Soil and bed preparation: i.e. Lay out of bed, sifting soil, levelling, tamping etc. 4 units/100' x 30", holding 7,500 useable plants. Unit cost per 1000 plants.	.533	
4.	Sowing: One unit can sow approximately 600 sq. ft. of bed with 12 lbs. pine seed per day. Unit cost to sow sufficient seed for 1000 plants is	.005	
4(a)	Cost of Seed. No data available take Department of Forestry tariff of R1.25 per lb. Cost of seed for 1000 transplants.		.200
5.	Pricking out,one unit can prick out 2,250 seedlings. Allowing 83% survival. Unit cost per 1000 useable plants is.	.520	
6.	Root pruning 4 units root prune 8 beds of 7,500 plants/day. (.067/1000 x 10 root-prunings). Unit cost of years root pruning/ 1000 plants.	.667	
7.	Watering, weeding and general maintenance (756 units for 600,000 plants) Unit cost/1000 plants.	1.260	
8.	Lifting and boxing of nursery plants. 1 unit can lift and fill 100 trays. Unit cost/1000 plants.	.286	
9.	Nursery raising and planting 600,000 plants requires total of 2,100 trays holding 35 plants to allow for lifting, resting and planting of approximately 24,000 plants daily. Trays last 2 seasons and cost 10 cents each. Total cost per 1000 plants.		.18
	Total/1000 plants.	3.599	.694

TABLE XIII.

Cost of Raising 1000 Pinus plants using the Combined Bed and Tray Method. Figures supplied by S.A. Forest Investments Ltd., from their Ramanas nursery, Transvaal.

		Units	Cash
1.	Cutting and preparing 20 Eucalyptus logs (8' x 3½") and pegs as retaining walls for 80' bed containing 6,700 useable plants requires 1 unit. Unit cost/1000 plants.	.149	
1(a)	Transport cost on eucalyptus logs. 1 trip for 5 ton lorry carrying 100 logs, haulage distance 5 miles at 13 cents/mile 130 cents for 5 beds or 33,500 plants. Cost/1000.		.04
2.	Soil Transportation. 5 ton lorry, driver and four labourers excavate and deliver 8 loads/day. 80,000 lbs. soil sufficient for 15 - 80' x 40" beds, each containing 6,700 useable plants. Unit cost/1000 plants.	.050	
2(a)	Cost of transport: Haulage distance 1½ miles at 15 cents per mile. 10,000 lbs. soil sufficient for 12,500 plants. Cost/1000 plants.		.04
3.	Soil and bed preparation. Sifting soil lay out of retaining walls, filling, levelling, tamping etc. 120 units for 30 beds each 80' x 40" holding 6,700 plants. Unit cost/1000 plants.	.597	
4.	Sowing. One unit can direct sow 3000 seeds. Allowing 83% survival -unit cost/1000 plants.	.390	
4(a)	Cost of Seed. Not available. Take F.D.tariff rate of R1.25 per lb.		.20
5.	Pricking out. Not done.		
6.	Root-Pruning. 125 units used for 230,000 plants. Tilbury root pruning frame used. Unit cost/1000 plants.	.543	
6(a)	Depreciation on frame and cost of wire for root-pruning 1000 plants/season.		.01
7.	Watering weeding and general maintenance (including erection of hail screens.). 495 units for 230,000 plants.Unit cost/1000 plants.	2.152	
8.	Lifting and boxing nursery plants 60 units for 230,000 plants. Unit cost/1000 plants.	.261	
9.	Trays used for transporting plants to field have life of 5 years. Cost per box 11 cents. No. required is 2,100 to allow for lifting, resting and planting of 24,000 plants per day.Total No.of plants raised 230,000.Cost/1000 plants.		.200
	Total Cost/1000 plants	4.140	.49

TABLE XIV.

Cost of Raising 1000 Pinus plants using the Combined Bed and Tray Method. Figures supplied by Twello Forestry Corporation Limited, Barberton, Transvaal.

		Units Cash	
1.	Manufacture of bed retaining walls from edged slabs, obtained free of charge: 4 units cut and fit 5 bed frames, each bed capable of holding 6,600 useable plants. Unit costs/1000 plants.	.121	
1(a)	Transport costs on wall material. Labour 3 units required for 2 loads by tractor and trailer for round trip of 20 miles. 2 loads sufficient for 50 beds or 330,000 plants Unit cost/1000 plants.	.009	
(b)	Transport costs on wall material. Tractor and trailer for mileage of 20 miles transport sufficient material for 25 beds or 165,000 plants. Cost/1000 plants.		.01
2.	Soil transportation. Five ton tip truck, 5 labourers and driver can deliver 10 beds or 66,000 plants. Unit cost/1000 plants.	.091	
2(a)	Costs of Transport on soil. Haulage distance 1 mile at 15 cents/miles. 1 load sufficient for 1 bed or 6,600 plants. Cost/1000 plants.		.05
3.	Soil and Bed Preparation. 1 labourer sifts 2 loads 8 cu.yards per day. 1 piccannin (juvenile units = ½ adult unit) fills 1 bed (4 cu.yards) per day and 1 piccannin levels 2 beds/ day. Units required to sift,fill and level 1 bed or 6,600 plants is 1¼ units. Unit cost/1000 plants.	.189	
4.	Sowing. 3 units sow 50 lbs/day, unit cost to sow sufficient P.elliottii seed to raise 1000 transplants (15,000 seeds/lb) germ capacity 90% plant percent 60%).	.007	
4(a)	Cost of Seed. Not available. Take F.D. tariff rate of R1.25 per lb. Cost of seed for 1000 useable transplants.		.20
5.	Pricking out. 3000 transplants pricked out per unit, allowing 83% survival. Unit cost/1000 useable plants.	.390	
6.	Root-pruning. 8 units can root,prune 50 beds of 6,600 plants (or 330,000) per day. Cost/1000 plants .024. Root-pruning done monthly 12 times/year. Total unit cost/ 1000 plants.	.288	
6(a)	Cost of Depreciation and interest on Root pruner frame and annual cost of wire.		.01
7.	Watering and Weeding. 1460 juvenile units or 730 full units on 330,000 plants. Unit cost/1000 plants.	2.212	
8.	Lifting, six units lift and box 2 beds or 13,200 plants in 1 day. Unit cost/1000 plants lifted.	.455	
9.	Cost of trays and equipment. Nursery uses 400 metal trays each costing .53 rand. Life of these trays not known, but Twello are taking 25% depreciation to allow for replacement. Lifting equipment charged to cost of trays at 25% depreciation. Total cost of trays and equipment R220.00 25% depreciation and 7% on capital outlay. R70.40 on 735,000 plants/yr.		.10
	Total cost/1000 plants.	3.762	.37

TABLE XV.

Cost of Raising 1000 Pinus plants in beds for open-rooted planting. Figures collected by the author from Experimental work at Elgin and Kruisfontein.

		Units	Cash
1.	Manufacture of 12' x 3' bed frames. Two men make frames in 2 days. (1000 useable plants per bed) Unit cost/1000 plants.	.083	
1(a)	Cost of material. 1" x 4" pressure treated with creosote..83 cu.ft./frame at .35 rand/cu.ft. Each frame useable for at least 3 seasons. Cost/1000 plants season.		.10
2.	Transport of soil. A 3 ton lorry, driver and 4 labourers move six loads/day. Sufficient for 40 frames or eight Frames/unit. Cost/1000 plants or 1 frame.	.125	
2(a)	Transport cost on soil for 1 frame, based on 11 cents per mile for 3 ton lorry and average haulage distance of 6.5 miles.		.21
3.	Filling and preparation of soil in frames: 4 men filled, raked and tamped 6 frames in 1 hour. Unit cost per 1000 plants.	.073	
4.	Sowing. Direct placing of seed at 2" x 2" espacement 1 man took 16 hours for 7344 seed- giving a unit rate of 4126. Unit cost of sowing for 1000 plants.	.242	
5.	Sowing and Pricking Out. 1 man pricked out 4900 plants in 15 hours giving rate of 2900/unit. Sowing taken as average for Elgin (.005) Unit cost of sowing and Pricking out.	.350	
5(a)	Cost of seed based on Dept. of Forestry tariff rate of R1.25 per lb.		.20
6.	Root-pruning. 2 men root prune 34 frames in 3 hours. Unit rate/1000 plants or per frame .020.		
6(a)	Direct sown plants root pruned 12 times in nursery.	.240	
(b)	Pricked out stock root pruned 11 times in nursery.	.220	
(c)	Cost of 220 lbs. cable wire 12 ft. length at 17 cents/yard (per frame for 1 year).		.68
7.	Watering weeding and general maintenance including bird guard. Unit cost/1000 plants.	1.491	
8.	Lifting of plants in preparation for transportation to planting site 1700 plants lifted by 3 men in 30 min. Unit cost/ 1000 plants.	.098	
	A. Situ sown.....	2.352	R1.19
	B. Pricked out.....	2.440	R1.19

Total cost/1000 plants.

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TABLE XVI.

Cost of Raising 1000 Pinus plants in beds 1960/61. Steenbras Nursery: Cape Town City Council.

Seed drill sown in beds which have been well worked but not raised in any way. No root pruning, wrenching or other root improvement technique is practised. Watering by can from drums filled by hose.

		Units.	Rand.
1.	Soil and Seed bed preparation. 30 units required to prepare area for raising 83,000 plants. Unit Cost/1000 plants.	.361	
2.	Sowings. Drill sowings, 1 unit sowing and covering 3 lbs. or 21,000 plants. Cost/1000 plants.	.048	
3.	Cost of Seed. All seed collected and separated by City Council but costs not kept separate. Taken as R1.25 per lb. standard tariff of Department of Forestry. Cost 1000/plants.		.20
4.	Watering. Required 26 days/month from Nov. to May and twice daily for 2½ months of this period. 3 men watering 83,000 plants in nursery in 2 hours, or .008 units/1000 plants.	1.976	
5.	Weeding and general nursery maintenance 240 units for 123,000 plants.	1.951	
6.	Lifting not available. Take Kruisfontein figure.	.098	
	Total Cost/1000 plants	4.434	.20

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TABLE XVII.

Cost of Raising 1000 Pinus radiata plants in Plastic Bags. Franschhoek Nursery.

+ Large Bag 5" x 7" 125 gauge holding 1 lb. 12 ozs. of nursery soil in normal workable condition (about 10% M.C.)

*Small bag 4" x 5" 125 gauge holding 14 ozs. of nursery soil in normal workable condition (about 10% M.C.)

		Large Bag+ Unit.	Large Bag+ Rand	Small Bag* Unit	Small Bag* Rand.
1.	Cost of Materials per 1000 bags.		1.25		
(b)	Not applicable - bags purchase ready for use.				.93
2.	Ditto.				
3.	Soil transportation. 3 ton lorry driver and 4 labourers can move six loads per day. Sufficient for 20,000 large and 40,000 small bags allowing for wasteage. Unit cost per 1000 bags.	.250		.125	
3(b)	Transport cost on soil for 1000 bags based on 11 cents per mile for 3 ton truck and average haulage distance of 6.5 miles.		.42		.21
4.	Preparation and filling of bags. Rate inversely proportional to bag size, larger bag is easier to fill. A unit filling between 800 and 900 large and between 500 and 600 small bags. Unit cost of filling and removing 1000 bags.	1.250		2.000	
5.	Sowing. One labourer can fill and sow 150 trays per day. Unit cost of filling and sowing 3 trays.	.020		.020	
5(a)	Cost of Seed per 1000 transplants. Seed cost taken at Departmental tariff of R1.25 per lb.		.20		.20
6.	Pricking out of seedlings. One labourer can prick out 2000 seedlings per day. Unit cost of pricking out 1000 seedlings.	.500		.500	
7.	Watering of plants, root-pruning where necessary. Weeding and general care of nursery for eight month period plants are in the nursery (Based on ¾ of annual cost of nursery as a whole - 528 units for 320,000 plants).	1.238		1.238	
	Total cost per 1000 plants	3.258 Units	1.87 Rand	3.883 Units	1.34 Rand

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TABLE XVIII

Cost of Raising 1000 Pinus plants under the Tray Method: Comparison of percentage of Total Cost required for various operations. (Unit cost taken as one rand).

Description of Operation.	Cost in Rand					% of Total Cost				
	1	2	3	4	Mean	1	2	3	4	Mean
1. Cost of Materials and Manufacture of Trays to hold 1000 plants (inc.tarring of trays where done).	4.02	4.04	4.58	3.29	3.98	49.3	57.1	61.2	42.9	52.4
2. Transport of soil	.07	.15	.11	.06	.10	0.9	2.1	1.5	0.8	1.3
3. Filling and preparation of trays for sowing and pricking out.	.36	.18	.43	.27	.31	4.4	2.5	5.7	3.5	4.1
4. Cost of seed and sowing thereof	.21	.21	.21	.21	.21	2.6	3.0	2.8	2.7	2.8
5. Pricking out	.50	.57	.80	.39	.56	6.1	8.0	10.7	5.1	7.4
6. Watering, weeding, root pruning and general maintenance.	3.00	1.93	1.35	3.45	2.43	36.7	27.3	18.0	45.0	32.0
Total Cost /1000 plants	8.16	7.08	7.48	7.67	7.59	100.0	100.0	100.0	100.0	100.0

TABLE XIX

Cost of Raising 1000 Pinus plants using the Combined Bed and Tray Method: Comparison of Percentage of Total Cost required for the various operations. (Unit Cost taken as one rand).

Description of Operation	Cost in Rand				% of Total Cost.			
	5	6	7	Mean	5	6	7	Mean.
1. Cost of Materials and Manufacture of beds	.41	.19	.14	.25	9.5	4.1	3.4	5.7
2. Transport of soil	.23	.09	.14	.15	5.3	2.0	3.4	3.4
3. Filling and preparation of beds	.52	.60	.19	.44	12.1	12.9	4.6	10.1
4. Cost of seed and sowing thereof	.21	.60	.21)	.65	4.9	12.9	5.1)	14.9
5. Pricking out (where done)	.53	not done	.40)		12.3	not done	9.6)	
6. Root Pruning using thepruning winch or Stubbing's pruning frame	.68	.55	.30	.51	15.8	11.9	7.2	11.7
7. Water, weeding and general maintenance	1.26	2.15	2.21	1.87	29.2	46.3	53.3	42.7
8. Lifting and boxing of Nursery plants	.29	.26	.46	.34	6.7	5.6	11.1	7.8
9. Cost of trays for transport of plants from nursery to field	.18	.20	.10	.16	4.2	4.3	2.4	3.7
Total Cost /1000 plants	4.31	4.64	4.15	4.37	100.0	100.0	100.0	100.0

TABLE XX

Cost of Raising 1000 Pinus plants in beds for Open-Rooted Planting: Comparison of Cost of the Various Operations. (Unit Cost taken as one rand)

Description of Operation.	Cost in Rand			% of Total Cost		
	Direct Sown	Sown and Pricked out	Steenbras	Direct Sown	Sown and Pricked out	Steenbras
1. Cost of materials and manufacture of bed frames (where used)	.18	.18	-	5.1	5.0	-
2. Soil and Seed bed preparation	.41	.41	.36	11.6	11.3	7.8
3. Cost of Seed and Sowing thereof	.44	.21	.25	12.4	5.8	5.4
4. Pricking out (where done)	-	.35	-	-	9.6	-
5. Root pruning (where done)	.92	.90	-	26.0	24.7	-
6. Watering, weeding and general maintenance	1.49	1.49	3.93	42.1	40.9	84.6
7. Lifting of plants including counting, culling and packing in preparation for transport to planting site.	.10	.10	.10	2.8	2.7	2.2
Total Cost / 1000 plants	3.54	3.64	4.64	100.0	100.0	100.0

TABLE XXI

Cost of Raising 1000 Pinus plants in plastic bags. (Unit cost taken as one rand)

		Cost in Rand		% of Total Cost	
		Large Bag	Small Bag	Large Bag	Small Bag
1.	Cost of 1000 plastic bags (125 gauge)	1.25	.93	24.4	17.8
2.	Soil transportation	.67	.34	13.0	6.5
3.	Filling and preparing bags for pricking out	1.25	2.00	24.4	38.2
4.	Cost of seed and sowing thereof	.22	.22	4.3	4.2
5.	Pricking out	.50	.50	9.7	9.6
6.	Watering, weeding, root pruning and general maintenance	1.24	1.24	24.2	23.7
	Total cost / 1000 plants	5.13	5.23	100.0	100.0

TABLE XXII.

Comparison of Mean Costs of Raising 1000 Pinus plants using Different Nursery Techniques: (Unit cost taken as one rand).

	Tray Method	Combined Bed & Tray Method.	Open-Rooted Method. (Direct Sown).	Plastic Bag Method. (Large 5"x7" bag).
Cost in Rand.	7.59	4.37	3.54	5.13
% of above total devoted to various operations.				
1. Cost of Tray Bag, bed wall etc.	52.4	9.4	5.1	24.4
2. Transport of soil and preparations for planting and or sowing.	5.4	13.5	11.6	37.4
3. Cost of Seed, Sowing and Pricking out.	10.2	14.9	12.4	14.0
4. Root Pruning.	inc. in 5 below	11.7	26.0	inc. in 5 below.
5. Watering and Weeding.	32.0	42.7	42.1	24.2
6. Preparation of Plants for transport to field.	-	7.8	2.8	-
	100.00	100.0	100.0	100.0

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TABLE XXIII.

Comparison of Costs of Watering Pine plants using flood irrigation (old method) and overhead sprinklers (new method).

Date Supplied by the Cape Town City Council from their 1 acre Wemmershoek Nursery: raising 250,000 plants annually.

Flood Irrigation (old method).	Overhead Spray (new method). Moveable.
1. Labour.	
5 units for 5 days/week Nov.- March (5 months) 20 weeks Total 500 units.	2 men for 1 hour 3 days per week i.e. 2/3 unit/week Nov. to March, (5 months) 20 weeks Total 13⅓ units.
2. Other Costs.	
Nil.	
Plants raised 250,000 *Cost per 1000 plants = 690 rand for 250,000 *Cost/1000 plants = R2.76 or 2 units.	Power paraffin used 12 gallons/ week. petrol ½ gal./week. 240 gals. power paraffin) season 10 gals. petrol and) of 20 25 pints engine oil.) weeks Cost of Spraying equipment R613.32

Difference in labour costs per season 486.5 units. Cost of unit R1.38. ∴Saving in labour in 1st season R671.37 - pays for initial outlay of the machine.

Total Cost for 250,000 plants with new system:-

R18.63 for labour
R43.80 for fuel
R61.33 for 10% depreciation.
} R123.76.

50 cents/1000 plants.

240 gals. of power/paraffin at 15 cents/gallon = R36.00
10 gallons petrol at 33 cents/ gallon = R3.30.
25 pints engine oil at 18 cents/ pint = R4.50
Total fuel costs = R43.80
= 31.74 units

(Power paraffin 44 gals. drum costs R6.59).

% Saving on watering costs per 1000 plants from old to new systems 82%.

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TABLE XXIV.

Comparison of Costs of Watering Pine plants using Watering Cans and overhead sprinklers. Data supplied by S.A. Forest Investments Ltd., from their 1 acre nursery at Hendriksdal raising 293,000 plants annually.

Watering Cans (old).	Overhead Spray (new).
1. Labour.	
2 units employed full time daily watering with watering cans except when raining. 500 units.	½ unit daily except when raining. Labour costs 1/6 of that under old system.
2. Other Costs.	Spray irrigation system gravity fed. no other working costs.
Nil.	
Plants raised 293,000. Unit cost of watering/1000 plants 1.706 units. Cost of unit R1.00 Cost of watering 1000 plants R1.71.	Cost of spraying system and installation thereof. Cost of equipment R212.43 Cost of installation 1½ units at R1/unit = R1.50. Total cost R213.93.

Difference in labour costs/season 416.66 units.
Cost of unit R1.00 ∴ Saving in labour during first season of operation R416.66 easily pays for initial outlay of spraying equipment and its installation.

Cost of watering under new system:-

Labour 83.66 units at R1 per unit
10% Depreciation on equipment R21.39

R105.05 Total cost of 293,000 plants.

Cost/1000 R0.36

% Saving on watering costs per 1000 plants from old to new systems 79%.

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CHAPTER VI.

DISCUSSION AND RECOMMENDATIONS.

The forester or nursery manager must examine the methods available to see if they produce satisfactory plants economically. The Tray Method can produce satisfactory plants. Initial survival is good and resumption of growth after planting is faster than that obtained with other methods, except the single plant method. Blanking is frequently required, however, on all but the most favourable sites. The average percentage blanking from all Forest Department plantings for the ten year period 1949-1959 was 25% (appendix 16). This includes all species and all sites and can be regarded as satisfactory.

THE COMBINED BED AND TRAY METHOD, gives equally satisfactory results, (Long, Keet and du Preez 1962), indeed at time of planting it is essentially a tray method. The resumption of growth after planting is appreciably influenced by the skill of the boxing crew, however, and indifferent or careless lifting not only increases the check period but can often so damage the plants as to cause their rejection. (Dally 1962).

Both the Tray and the Combined Bed and Tray Methods can be used with confidence in any of the forest regions of South Africa. Some trouble has been experienced with the Combined Bed and Tray Method in Zululand due to the very sandy and non-binding nature of the soil (Gray 1962). Soil texture is an adjustable feature, however, and should not prove insurmountable.

These two major methods, the Tray and the Combined Bed and Tray Methods are both capable of producing satisfactory planting material and the question of which to use is largely economic.

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The Combined Bed and Tray Method is appreciably cheaper than the Tray Method and growers producing plants for their own use should use it. Where plants are grown for sale, however, there will be little advantage in changing from the Tray to the Combined Bed and Tray Method until an efficient system of box recovery is worked out. Costs, other than box costs, are very similar for the two methods and without an efficient box recovery rate, savings would be negligible. The Open-rooted Method deserves serious consideration within the constant and winter rainfall regions of the country, especially on southern and eastern aspects where satisfactory survival and subsequent growth are assured.

Pinus radiata, Pinus taeda, and Pinus elliottii can all be raised satisfactorily in beds and planted open-rooted. Pinus pinaster, although capable of withstanding considerable root exposure when fully dormant, is much more susceptible to weather and seasonal changes than the other pines and should be raised by the Tray or Combined Bed and Tray Methods. Plant size, between 6 and 10 inches, has little effect on the suitability of the Southern pines but appreciably influences the percentage survival and initial growth of open-rooted Pinus radiata. A plant of 10 to 12 inches, with a collar diameter of about .65 mm. and a root shoot ratio of .60 is recommended for Pinus radiata.

The major advantages of the open-rooted method are economical. Plants grown in beds grow faster and require a shorter period in the nursery. Savings are made throughout the nursery period.

Where plants are to be lifted and planted open-rooted, seed should be direct sown in drills at the desired espacement. Direct sown plants grow faster and give a significantly better plant percent than pricked out stock. (Plate IV).

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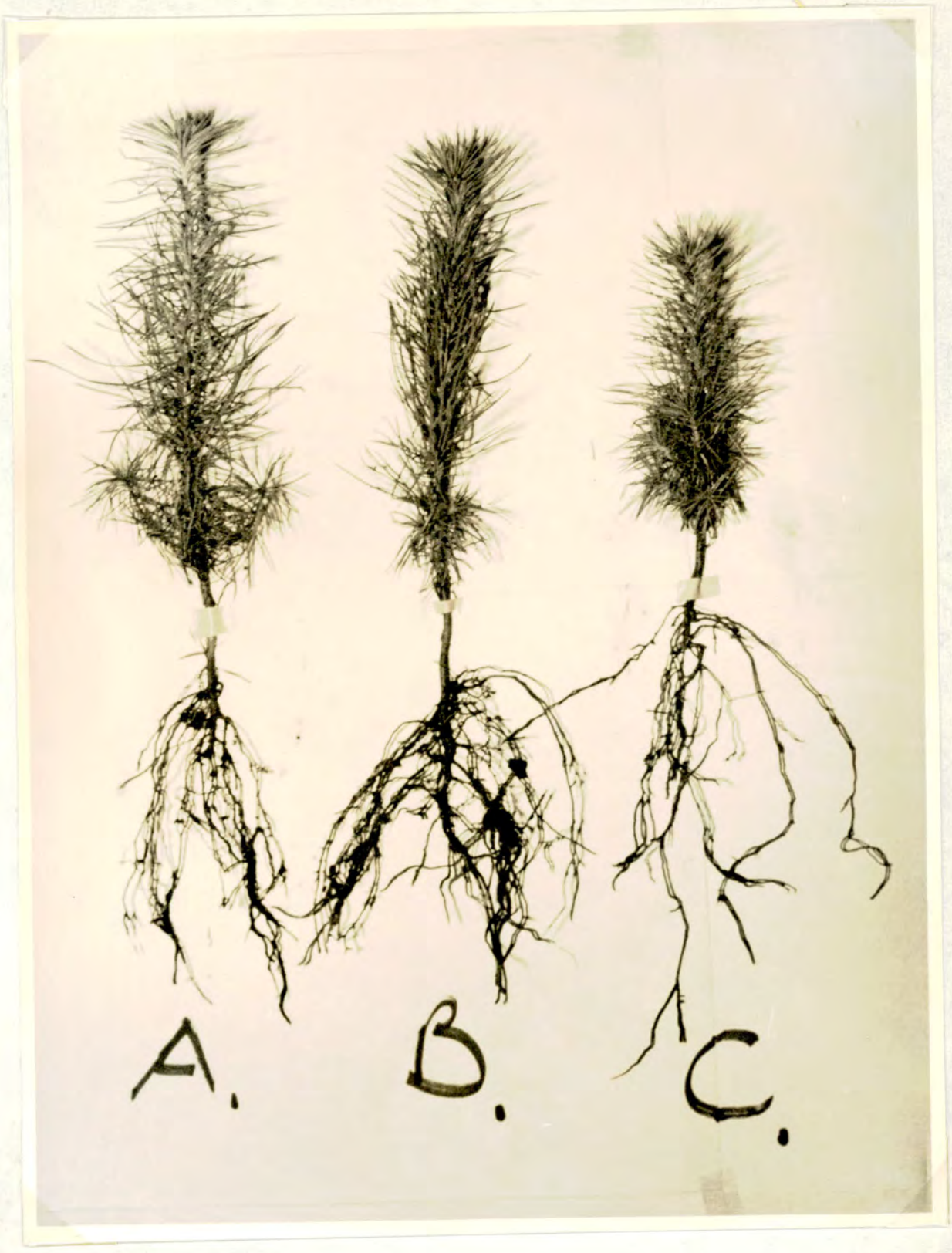

Plate IV.

Effect of Methods of Sowing on the development of Pinus radiata transplants.
A. Broadcast Sown; B. Drill Sown; C. Densely Sown and pricked out.

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Provided root-pruning is done there will be no difference in the R/S ratios of direct sown and pricked out stock.
To facilitate root-pruning beds should be revetted and raised 5 to 6 inches above the nursery level. Root-pruning should be done with a Tilbury pruning frame as designed by Stubbings (1958), though where a suitable tractor is available pruning should be mechanised.

While it is possible to grow pines that have been pricked out without further root-pruning, it cannot be recommended and regular root-pruning should be taken as a sine qua non for the production of open-rooted plants.

Desiccation of the roots of open-rooted plants is the major cause of failure. Some exposure during lifting and grading is unavoudable but should be kept to a minimum. Once lifted and pruned all further sorting, counting and culling operations should be done under cover to prevent undue exposure of the roots to sun and wind. Plants must be protected when carried from the beds to the sorting shed.

When fully dormant P.radiata can withstand root exposure of up to 40 minutes without directly affecting percentage survival. Pinus elliottii and Pinus taeda cannot withstand periods of more than 30 minutes, after which percentage survival is significantly reduced. Root exposure affects not only percentage survival but also the period of check before growth recommences. The longer the period of root exposure the greater the check period. In the Western Province this can indirectly affect percentage survival as plants which withstand the initial planting operation frequently have insufficient time to become firmly established and may be killed by the summer droughts of January and February.

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When ready for dispatch to the planting site plants should be wrapped in wet sacking or placed in large polythene bags. For short transit periods either material is satisfactory, but for periods longer than 48 hours polythene would be preferable, as sacking tends to dry out. Polythene, although initially more expensive, has a longer life and is easier and lighter to handle. Direct exposure to sunlight must be avoided as plants packed in polythene heat dangerously if so exposed.

On delivery at the planting site plants should be trenched. Pinus radiata, P.taeda and P.elliottii can be trenched for up to one week without adversely affecting percentage survival, provided the plants are dormant. Plants are removed from the trenches for planting when required. If it is necessary to stop planting, for any reason, unused plants should be replaced in the trench.

The period of greatest danger from exposure is during the actual planting operation. The forest labour must be taught the dangers of exposure to the roots, and supplied with a suitable plant carrying bag to protect the plants. A rough bag can be made from a half sack, but a more satisfactory one can be made from 600 gauge white polythene. It should be fifteen inches deep, eighteen inches wide at the bottom and nine inches wide at the mouth. A four inch flap covers the mouth and the whole is carried over the shoulder on a shoulder strap. A layer of damp moss or peat is placed at the bottom of the bag to keep the contents moist. Plants must remain in the bag until they are taken out for insertion in the soil.

Planting can be done by trowel but a preferable and faster method is to use a worn garden spade and plant with a T or L notch.

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The education of the forest labour in the use of open-rooted planting material cannot be sufficiently stressed. Both percentage survival and planting costs can be improved through proper technique, and until the labour is familiar with the correct procedure constant supervision is necessary.

The costs of open-rooted planting are less than the two major systems at present in use and the method deserves serious consideration in all areas where it is likely to give reliable results. In both the Cape Midlands and the Western Cape it is recommended for Pinus radiata, P.taeda and P.elliottii on all better quality sites with south and east aspects.

THE PLASTIC BAG METHOD.

The use of 5" x 7", 125 gauge plastic bags for the production of pine nursery stock has increased percentage survival on hot sandy sites in the Western Province which have proved difficult to afforest. The costs of production compare favourably with the Tray Method and their use for difficult sites of this nature is recommended. The use of plastic bags is not economically justifiable on more favourable sites where cheaper methods will give reliable results.

GENERAL RECOMMENDATIONS.

The nursery methods available for the production of pine transplants yield plants suitable for different types of sites, and the nursery man should use the cheapest method which gives the results.

The Tray Method should be confined to nurseries raising plants for sale.

The Combined Bed and Tray Method should be the major nursery method in use in Southern Africa. It should be used by all private growers in the summer rainfall regions for all but the most difficult sites, where the plastic bag method should be adopted. In the winter and constant rainfall regions its use should be confined to northern sites with western aspects.

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The Open-rooted Method, should be used throughout the winter and constant rainfall areas for the production of P.radiata, P.elliottii and P.taeda transplants for south and east aspects. On the warmer north and westerly aspects blanking is generally required, and open-rooted plants should be used with caution.

The Plastic Bag Method. This method is recommended for all sites which are difficult to afforest by the previous methods.

Costs can be appreciably and safely reduced if the nursery man uses several methods simultaneously to produce plants for the different types of sites he has to plant. None of the methods is difficult and he should not be afraid to tackle any method his planting site might warrant.

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Appendix 1.

Extract from the Annual Report of the Conservator of Forests, 1900.

98a/.....

APPENDIX A.—TOKAI PLANTATION.

Nursery Return, 1900.

Species.	Stock on hand 31st Dec., 1899.	Raised during 1900.	Total.	Supplied to other Forest Stations.	Sold to Public.	Planted at Tokai.	Otherwise disposed of.	Stock on hand 31st Dec., 1900.
Aberia caffra	15,250	..	15,250	..	15,200	..	..	50
Abies douglasii	210	..	210	..	..	..	180	30
,, armata	130	..	130	..	..	..	.	130
Acacia baileyana	560	.	560	..	46	..	302	212
,, binervata	112	..	112	.	..	6	16	90
,, cultriformis	1,172	..	1,172	..	88	14	721	349
,, acinacea	2	..	2	..	2	..	..	..
,, cyclopis	1,760	..	1,760	..	431	..	229	1,100
,, decurrens	1,777	600	2,377	..	310	..	8	2,059
,, falcata	200	..	200	..	..	40	136	24
,, hispidula	3	..	3	..	..	..	..	3
,, juniperana	150	..	150	..	..	40	20	90
,, longifolia	200	..	200	..	..	40	30	130
,, melanoxylon	104,225		104,225	..	45	91,176	198	12,806
,, obtusa	100	..	100	..	..	..	92	8
,, oswaldii	20	..	20	..	..	..	5	15
,, pycnantha	326	1,000	1,326	..	25	20	81	1,200
,, pendula	3	..	3	..	..	..	2	1
,, primosa	100	..	100	..	..	40	45	15
,, saligna	435	1,400	1,835	..	262	13	..	1,560
,, species	2,000	..	2,000	..	..	1,791	..	209
,, harpophylla	..	1,000	1,000	..	..	..	..	1,000
Acer palmatum	32	..	32	..	..	..	2	30
,, pseudoplatanus	50	..	50	..	..	..	10	40
,, rubrum	15	..	15	..	..	..	11	4
Aesculus hippocastanum	6	..	6	..	..	..	..	6
Agonis flexuosa	554	..	554	..	9	179	..	366
Ailanthus glandulosa	43	..	43	..	..	..	8	35
Alnus glutinosa	9		9	..	..	..	..	9
Angophora lanceolata	4,045	1,350	5,395	..	100	..	35	5,260
Araucaria bidwillii	1	..	1	..	..	..	..	1
,, cunninghamii	1	..	1	..	1	..	..	..
,, excelsa	186	.	186	..	59	..	10	117
Berberis thumbergi	1	..	1	..	..	..	..	1
Bignonia tweediana	1	..	1		.	..	..	1
,, capriolata	128	..	128	..	..	..	20	108
Betula nana	10	..	10	..	..	..	..	10
Buxus sempervirens	4	..	4	..	..	..	1	3
Callistemon incarris	100	..	100	..			60	40
,, lanceolatus	100	..	100	..	..	..	50	50
,, rigidus	400	..	400	..	..	..	84	316
,, salignus	586	..	586	16	130	..	34	406
Casuarina distyla	150		150	..	..	..	25	125
,, equisetifolia	350	800	1,150	..	25	..	45	1,080
,, glauca	266	..	266	..	..	..	46	220
,, quadrivalvis	134	600	734	.	13	..	12	709
,, leptoclada	145	..	145	7	..	..	8	130
,, lepidophloia	24	..	24	..	..	.	..	24
,, paludosa	90	..	90	..	..	..	42	48
,, suberosa	449	..	449	..	3	..	..	446
,, torulosa	175	..	175	..	..	..	55	120
,, tennuissima	32	..	32	.	..	..	..	32
Calycanthus glaucus	12	..	12	..	..	..	1	11
Caragana arborescens	50	..	50	..	..	..	47	3
Cassia brewsterii	4	..	4	..	..	..	1	3
Castenea vesca	106	..	106	..	2	12	67	25
Callitris australis	160	..	160	..	..	..	48	112
,, brachyandrus	10	..	10	..	..	..	..	10
,, calcarata	8,000	7,000	15,000	..	..	..	..	15,000
,, cupressoides	1,453	..	1,453	1,010	1	8	220	214
,, muellerii	4	..	4	..	.	..	..	4
,, robusta	5,064	2,000	7,064	4,000	150	..	190	2,724
,, whytei	1,800	..	1,800	900	..	38	618	244
,, verrucosa	5,000	..	5,000	4,000	..	..	600	400
,, rhomboidea	106	..	106	100	6	..	..	..
Catalpa bignonoides	1,950	..	1,950	..	25	..	125	1,800
,, radicans	100	..	100	..	..	..	40	60
,, speciosa	1,150	..	1,150	..	..	..	450	700
Ceratonia siligna	175	..	175	..	2	54	53	66

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APPENDIX A.—TOKAI PLANTATION.

Nursery Return, 1900—*continued.*

Species.	Stock on hand 31st Dec., 1899.	Raised during 1900.	Total.	Supplied to other Forest Stations.	Sold to Public.	Planted at Tokai.	Otherwise disposed of.	Stock on hand 31st Dec., 1900.
Ceretopetalum gummiferum	100	..	100	..	1	..	59	40
Cedrela australis	50	..	50	..	..	..	3	47
Cercis siliquastrum	50	200	250	..	..	..	1	249
Cedrus atlantica	660	..	660	..	..	..	40	620
,, deodara	123	..	123	..	1	..	97	25
,, libani	20	..	20	..	..	..	..	20
Cedar of M'Lange	600	..	600	..	..	..	50	550
Celtis australis	8	..	8	..	..	..	6	2
Cinnamomum camphora	4,727	16,000	20,727	..	16	139	..	20,572
Cistus laurifolius	100	..	100	..		..	.	100
,, vaginatus	100	..	100	..	..	..	50	50
Colpoon cupressum	420	..	420	..	..	..	308	112
Colutea crucuta	80	..	80	..	..	..	8	72
,, arborescens	225	.	225	..	..	..	33	192
Cordyline australis	300	..	300	..	103	..	33	164
Cryptomeria japonica	315	..	315	..	..	25	..	290
Cupressus australis	1,480	..	1,480	..	..	..	8	1,472
,, bedfordiana	900	..	900	..	..	..	816	84
,, elegans	126	..	126	..	20	..	106	..
,, expansa	5,800	..	5,800	..	100	5,436	..	264
,, fragrans	1,088	..	1,088	..	..	..	944	144
,, goveniana	2,678	..	2,678	21	9	2,010	..	638
,, guadalupensis	2,610	..	2,610	..	102	1,938	..	576
,, lambertiana	4,000	..	4,000	..	..	3,700	..	300
,, lawsoniana	4,277	..	4,277	75	55	4	3,187	956
,, lusitanica	7,880	..	7,880	..	78	7,058	.	744
,, ,, glauca	420	..	420	.	..	420	..	..
,, macrocarpa	34,986	..	34,986	..	6,097	6,762	..	22,127
,, majestica	670	..	670	..	87	183	..	400
,, pendula glauca	5	..	5	..	..	..	5	..
,, horizontalis	63,956	..	63,956	4,430	5,050	50,976	..	3,500
,, pyramidalis	2,335	..	2,335	..	1,252	939	..	144
,, sinensis	2,778	..	2,778	..	188	162	12	2,416
,, torulosa	7,339	..	7,339	..	47	5,436	..	1,856
,, ,, var. gracilis	427	..	427	..	20	..	32	375
,, tournefortiana	260	.	260	..	..	40	28	192
,, thyoids	1	..	1	..	..	..	..	1
,, uzdeona	6,000	..	6,000	..	..	5,398	..	602
,, macnabiana	37	..	37	..	..	37	..	..
Curtisia faginea	1,000	..	1,000	5	..	..	467	528
Cytisos laburnum	9	..	9	..	..	..	..	9
Ekebergia capensis	137	..	137	..	4	..	29	104
Erythrina caffra	3	..	3	..	..	..	3	..
Eucalyptus obcordata	100	..	100	..	..	..	100	..
,, acmenoides	26,960	..	26,960	..	115	20,654	..	6,191
,, amygdalina	1,585	1,800	3,385	..	431	10	..	2,944
,, ,, var. radiata	650	..	650	..	..	..	..	650
,, ,, var. risdonii	600	..	600	..	..	..	400	200
,, botryoides	600	..	600	..	..	..	525	75
,, capitellata	100	.	100	..	..	..	99	1
,, calophylla	250	600	850	25	..	..	25	800
,, crebra	125		125	..	..	..	95	30
,, citriodora	670	1,800	2,470	..	58	..	36	2,376
,, coriacea	38	..	38	..	..	..	..	38
,, cornuta	10,786	13,500	24,286	..	8,736	..	79	15,471
,, corymbosa	162	..	162	..	..	..	54	108
,, corynocalyx	57,814	22,000	79,814	39,210	9,161	947	..	30,496
,, diversicolor	218,859	..	218,859	9,000	7,788	111,658	..	90,413
,, eugenoides	21	..	21	..	..	..	21	..
,, ficifolia	4,949	..	4,949	20	1,152	..	157	3,620
,, globulus	10,273	14,000	24,273	..	9,497	..	56	14,720
,, gomphocephala	1,064	2,700	3,764	..	1	..	231	3,532
,, gunnii	47	..	47	..	7	..	..	40
,, haemastoma	75	..	75	..	3	28	..	44
,, hemiphloia	230	3,200	3,430	7	3	..	8	3,412
,, ,, var. albens	..	700	700	..	..	..	..	700
,, lehmanii	150	..	150	..	..	40	30	80
,, leucoxylon	67,800	..	67,800	3,009	447	43,915	..	20,42
,, longifolia	4,500	4,200	8,700	..	121	11	..	8,568

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APPENDIX A.—TOKAI PLANTATION.

Nursery Return, 1900—*continued.*

Species.	Stock on hand 31st Dec., 1899.	Raised during 1900.	Total.	Supplied to other Forest Stations.	Sold to Public.	Planted at Tokai.	Otherwise disposed of.	Stock on hand 31st Dec., 1900.
Eucalyptus macrandra ..	50	..	50	..	..	40	10	..
,, macroryncha ..	750	600	1,350	200	..	..	..	1,150
,, marginata ..	2,661	4,700	7,361	..	301	12	..	7,048
,, maculata ..	150	10,500	10,650	..	..	..	..	10,650
,, melliodora ..	830	200	1,030	20	2	..	8	1,000
,, megacarpa ..	100	150	250	..	..	..	95	155
,, microcorys ..	14,410	..	14,410	..	2	4,264	..	10,144
,, obliqua	500	450	950	..	..	..	..	950
,, occidentalis ..	3	..	3	..	..	..	..	3
,, obtusiflora ..	10	..	10	..	..	..	1	9
,, obcordata .	25	..	25	..	..	..	..	25
,, paniculata ..	7,310	9,000	16,310	..	232	562	..	15,516
,, patens	..	2,500	2,500	..	..	..	..	2,500
,, pilularis ..	57,280	..	57,280	8	724	40,531	..	16,017
,, propinqua ..	100	..	100	..	1	99	..	..
,, punctata ..	9,860	..	9,860	..	..	4,390	..	5,470
,, pulverulenta ..	30	..	30	..	..	..	..	30
,, regnans ..	9,000	..	9,000	..	500	4,664	..	3,836
,, redunca ..	11,025	..	11,025	..	..	10,005	..	1,020
,, resinifera ..	7,400	2,500	9,900	..	1,146	13	..	8,741
,, ,, var. grandiflora	100	..	100	..	.	10	..	90
,, robusta ..	2,072	..	2,072	..	..	1,942	..	130
,, rostrata ..	2,497	..	2,497	1,933	388	84	..	92
,, rudis	100	..	100	..	..	..	..	100
,, saligna	2,940	..	2,940	..	..	904	..	2,036
,, salmonophloia ..	360	..	360	300	..	..	60	..
,, sideroxylon ..	3,110	..	3,110	2,000	100	..	..	1,010
,, sieberiana ..	50	..	50	..	..	..	42	8
,, stricta	75	..	75	..	..	40	20	15
,, siderophloia ..	8,650	..	8,650	..	108	3,385	..	5,157
,, stuartiana ..	500	..	500	..	..	240	..	260
,, tereticornis ..	22,303	..	22,303	..	807	17,992	..	3,504
,, urnigera ..	50	..	50	..	..	26	..	24
,, virgata	560	75	635	..	..	..	55	580
,, viminalis ..	475	900	1,375	15	..	..	..	1,360
Ficus australis	50	..	50	..	..	.	49	1
,, bellingera	50	..	50	..	..	..	..	50
,, macrophylla	117	..	117	..	10	..	15	92
Fraxinus excelsior, var. australis	250	..	250	..	..	..	..	250
,, americana ..	4,460	..	4,460	..	..	1,960	..	2,500
,, excelsior	7,800	..	7,800	..	..	7,228	72	500
,, ,, var. kabylia	9,520	..	9,520	..	..	3,020	..	6,500
,, ornus	6,832	..	6,832	..	..	1,832	..	5,000
,, platycarpus ..	35	..	35	..	..	..	5	30
,, pubescens ..	16	..	16	..	..	..	8	8
,, americana, var. alba	200	..	200	..	..	..	..	200
Frenela robusta	42	..	42	..	..	..	..	42
Ginkgo biloba	293	..	293	..	15	..	278	..
Gonioma kamassi	726	800	1,526	..	4	70	12	1,440
Grevillea robusta	460	300	760	..	106	..	22	632
Gleditschia triacanthos ..	260	..	260	..	..	..	20	240
Hakea gibbosa	..	4,000	4,000	..	3,590	..	410	..
Halesia corymbosa	25	..	25	..	..	..	1	24
Hedera helix	1	..	1	..	..	..	..	1
Ilex paraguayensis	3	..	3	..	..	..	..	3
Indigophora species ..	6	..	6	..	..	..	..	6
Juglans cinerea	156	..	156	..	..	..	136	20
,, nigra	56	..	56	..	..	2	54	..
,, sieboldiana ..	30	..	30	..	..	..	.	30
Juniperus bermudiana ..	3,570	..	3,570	..	9	4	..	3,557
,, drupacea ..	54	..	54	..	..	..	..	54
,, communis ..	596	..	596	..	..	..	46	550
,, lycia	175	..	175	..	..	..	100	75
,, phoenicia ..	650	..	650	..	..	2	..	648
,, virginiana ..	500	..	500	..	..	..	52	448
,, smirca . ..	5	..	5	..	..	..	..	5
Kiggelaria africana ..	1,439	..	1,439	..	6	1,425	..	8
Leptospermum laevigatum ..	112,050	115,000	227,050	..	106,650	..	..	120400
Lemon wood ..	13	..	13	..	13	.	..	..

APPENDIX A.—TOKAI PLANTATION.

Nursery Return, 1900—*continued.*

Species.	Stock on hand 31st Dec., 1899.	Raised during 1900.	Total.	Supplied to other Forest Stations.	Sold to Public.	Planted at Tokai.	Otherwise disposed of.	Stock on hand 31st Dec., 1900.
Leucadendron argenteum ..	146	..	146	..	10	..	..	136
Ligustrum japonicum ..	4,050	..	4,050	..	..	2,850	..	1,200
,, ovalifolium ..	10,000	..	10,000	..	..	..	..	10,000
,, vulgare ..	7,000	..	7,000	..	500	..	..	6,500
Liriodendron tulipifera ..	720	..	720	..	14	..	306	400
Livistona australis	73	..	73	..	4	..	25	44
Lycium horridum ..	2,300	500	2,800	..	350	..	50	2,400
Mallotus japonica	150	..	150	..	..	..	110	40
Melaleuca leucadendron ..	58	..	58	..	1	..	57	..
,, armillaris ..	36	..	36	..	..	..	..	36
,, salignus	160	..	160	..	..	..	160	..
,, paroiflora ..	50	..	50	..	..	..	..	50
,, imrifolia.. ..	100	..	100	..	..	..	..	100
,, squamea ..	150	..	150	..	..	..	85	65
,, hyprcifolia ..	60	..	60	..	..	..	..	60
,, stypheloides ..	80	..	80	..	..	..	..	80
,, thymifolia ..	100	..	100	..	..	..	..	100
Melia azedarach	484	..	484	..	109	..	75	300
Millitia caffra	24	..	24	..	..	..	4	20
Myrsine urvillei	40	..	40	..	5	..	7	28
Myrica cordifolia	3,400	..	3,400	3,360	..	..	40	..
Morus alba	900	..	900	..	..	..	..	900
Myoporum insulare ..	2,600	..	2,600	..	500	..	372	1,728
Mephelium tomentosum ..	2	..	2	..	..	..	..	2
Olea laurifolia	45	..	45	..	..	..	..	45
Omalanthus populifolium ..	9	..	9	..	..	..	..	9
Pistacea lentiscus	90	..	90	..	1	..	1	88
,, terebinthus ..	8	..	8	..	..	..	..	8
Ptaeroxylon utile	315	..	315	..	5	80	70	160
Pavonia hastata	20	..	20	..	..	..	..	20
Platanus occidentalis ..	2,100	..	2,100	25	18	..	57	2,000
Pittosporum bracteolatum ..	2	..	2	..	..	..	..	2
,, tuberaefolium ..	1	..	1	..	1	..	..	..
,, undulatum ..	220	..	220	..	2	..	5	213
Podocarpus elata	1	..	1	..	..	..	..	1
,, totora	13	..	13	..	..	..	..	13
Populus fastigiata	2,700	..	2,700	..	566	..	134	2,000
Poiniciana gilliesii	696	..	696	..	..	..	..	696
Pyrus cydonia	2,350	..	2,350	..	150	..	..	2,200
Plumbago capensis ..	850	..	850	..	750	..	..	100
Psamma arenaria	4,100	..	4,100	..	4,100	..	..	..
Pinus australis	17	1,500	1,517	..	..	17	..	1,500
,, canariensis	21,737	46,000	67,737	13,500	3,138	..	149	50,950
,, halepensis	37,837	..	37,837	..	620	13,217	..	24,000
,, excelsa	23	..	23	..	..	..	..	23
,, insignis	25,250	..	25,250	375	2,153	22,522	..	200
,, laricio	1,500	..	1,500	..	..	..	..	1,500
,, longifolia	4,000	3,600	7,600	..	..	..	..	7,600
,, mitis	10,000	1,000	11,000	..	..	..	..	11,000
,, muricata	579	25,000	25,579	19	25	..	135	25,000
,, pinaster	200	..	200	..	190	..	6	4
,, ,, var. gigantea	2,000	10,000	12,000	..	2,000	..	..	10,000
,, ,, ,, hamiltonii	50,000	..	50,000	..	3,625	6,375	..	40,000
,, ponderosa	83	..	83	..	..	3	..	80
,, strobus	100	..	100	..	..	..	5	95
,, thunbergii	1,100	..	1,100	..	..	..	50	1,050
,, torreyana	8	..	8	..	..	..	3	5
,, tuberculata	50	..	50	..	..	..	2	48
,, taeda	3,000	9,100	12,100	..	..	..	..	12,100
,, pungens	100	..	100	25	..	3	72	..
Punica granatum	250	..	250	..	..	..	..	250
Quercus pedunculata ..	125,400	..	125,400	40	5,328	..	32	120000
,, rubra	50	..	50	..	..	..	10	40
,, suber	165	1,600	1,765	4	..	..	18	1,743
Rhus coriacea	15	..	15	..	..	..	5	10
,, viminalis	..	800	800	..	..	..	..	800
Robinia pseudacacia ..	12	..	12	..	..	..	..	12
Raphiolepis indica	4	..	4	..	..	..	..	4
Sabal blackburniana ..	14	..	14	..	..	..	..	14

APPENDIX A.—TOKAI PLANTATION.

Nursery Return, 1900—*continued.*

Species.	Stock on hand 31st Dec., 1899.	Raised during 1900.	Total.	Supplied to other Forest Stations.	Sold to Public.	Planted at Tokai.	Otherwise disposed of.	Stock on hand 31st Dec., 1900.
Salisburia adiantifolia ..	80	..	80	..	..	..	..	80
Salix alba	958	3,000	3,958	..	..	..	58	3,900
,, amygdalina ..	958	10,000	10,958	..	..	..	58	10,900
,, caprea	4,950	3,600	8,550	..	..	..	50	8,500
,, pupurea	1,000	100	1,100	..	..	..	..	1,100
,, species	25,000	..	25,000	..	..	16,000	..	9,000
,, viminalis ..	4,000	..	4,000	..	..	8	392	3,600
Sandal wood	..	30	30	..	..	..	..	30
Schinus molle	1,061	..	1,061	..	435	391	..	235
Sequoia sempervirens ..	650	200	850	..	..	..	50	800
Sophora japonica ..	170	..	170	..	..	.	50	120
Syncarpia laurifolia ..	1,200	200	1,400	..	..	..	..	1,400
Taxodium distichum ..	232	..	232	..	..	..	96	136
Tecoma stans	21	..	21	..	1	..	..	20
,, var. veluntina ..	27	..	27	..	..	..	..	27
Tristanea conferta ..	3,352	..	3,352	..	24	2,563	5	760
Thuja gigantea ..	266	..	266	..	..	..	170	96
Tilia americana ..	15	..	15	..	..	..	7	8
Zyzyphus mucronatus ..	170	..	170	..	..	..	20	150
Zanthoxylon capense ..	20	..	20	..	..	..	1	19
Zelkova accuminata ..	18	..	18	..	..	..	..	18
,, keaki .. .	17	..	17	..	..	..	..	17
Miscellaneous	500	..	500	500	..	..	..	..
Totals ..	1,419,592	364,355	1,783,947	88,159	207,024	530,171	17,892	940,701

APPENDIX B.—TOKAI PLANTATION.

Rainfall Returns, 1895—1900.

Month.	1895.	1896.	1897.	1898.	1899.	1900.	Annual Average.
January	1·05	1·08	0.73	1·45	1·03	1·08	1·07
February	Nil.	1·04	0·39	0·72	0·45	0·84	0·57
March	1·26	4·43	2·12	2·07	0·71	1·64	2·04
April	4·50	0·59	1·85	6·17	2·22	0·67	2·67
May	5·22	2·88	2·29	6·73	4·70	3·99	4·3
June	4·83	2·80	6·52	8·17	2·88	2·53	4·62
July	2·52	7·28	8·86	10·42	5·66	7·43	7·03
August	4·80	3·46	3·50	3·63	12·73	6·50	5·77
September	5·12	2·67	3·01	3·54	1·96	2·57	3·15
October	1·90	1·53	4·07	4·15	4·82	3·58	3·34
November	1·89	1·82	0·80	2·40	1·48	0·85	1·54
December	2·02	Nil.	1 39	1·11	1·77	1·53	1·3
	35·11	29·58	35·53	50 56	40·41	33·21	37·4"

APPENDIX 2

AREA AFFORESTED AND PLANTS RAISED BY DEPARTMENT OF FORESTRY FOR ITS OWN USE AND FOR SALE TO THE PUBLIC 1910 - 1960

Period	Area Afforested By Dept. of Forestry.	Plants raised for Sale and Gratis Issue.	Plants for Dept. own use.*	Total plants raised.
1910-15	26,646	17,892,053	44,137,089	62,029,142
1916-20	18,231	21,996,772	25,354,815	47,351,587
1921-25	42,953	23,630,463	52,251,330	75,881,793
1926-30	72,435	20,325,986	85,914,588	106,240,574
1931-35	83,535	17,553,170	78,117,048	95,670,218
1936-40	73,487	22,004,555	96,363,224	118,367,779
1941-45	19,995	23,500,000	20,770,295	44,270,295
1946-50	77,855	58,689,821	54,203,949	112,893,770
1951-55	95,914	76,631,077	70,106,383	146,737,460
1956-60	107,883	69,842,120	69,842,120	88,175,869

* Plants raised for Department of Forestry's own use not available; estimated from acreages planted and espacements used for each decade. See notes with decade figures.

100/.....

PLANTS RAISED BY DEPARTMENT OF FORESTRY: 1910-1919/1920.

Year	Departmental Afforestation	Sale to Public and Gratis Issue	Blanking	Regeneration (Soft wood only)	Total
1910	5,339,503	3,059,021			
1911	9,545,640	2,806,402			
912/13	16,549,923	5,277,045			
913/14	11,136,000	3,772,192			
914/15	3,901,080	2,977,393			
Total	46,472,146				

Departmental Afforestation for 5 year period reduced by 6,347,520 to allow for 3,648 acres of Pinus pinaster and Wattle established by sowing.

orrected Totals 910-1914/15	40,124,626	17,892,053	4,012,463*	-	62,029,141
915/16	4,148,456	3,184,655			
916/17	4,619,700	3,135,803			
917/18	6,318,914	4,558,652			
918/19	7,198,606	5,279,484			
919/20	9,436,316	5,838,178			
Total	31,721,992				

Departmental Afforestation for 5 year period reduced by 8,672,160 to allow for 4,984 acres Pinus pinaster and Wattle established by sowing.

orrected Totals 915/16-1919/20	23,049,832	21,996,772	2,304,983*	-	47,351,587

1740 plants/acre

Note: During the decade very close espacements were used, generally 4' x 4', 5' x 5' and 6' x 6'.

The following pines were established at 4' x 4' :

Pinus halepensis, Pinus insignis, Pinus palustris, Pinus canariensis and Pinus teada. All other species were established at 5' x 5' or 6' x 6' e.g. P. caribaea, P.teada, P. patula all eucalypts and most other conifers and hardwoods. An average espacement of 5' x 5' has been used to estimate planting stock raised for Dept. Afforestation.
No regeneration of any consequence was carried out during this decade.

* An allowance of 10% of corrected afforestation total has been made for blanking. Plants used for blanking not recorded separately until 1934/35.

101/.....

PLANTS RAISED BY DEPARTMENT OF FORESTRY 1920/21-1929/30.

Year	Departmental Afforestation	Sale to Public and Gratis issue	Blanking	Regeneration (soft wood only)	Totals
1920/21	10,088,520	4,753,260		-	
21/22	12,320,940	5,102,920		170,520	
22/23	10,805,400	5,072,423		302,760	
23/24	18,499,680	4,228,970		186,180	
24/25	23,023,680	4,472,890		-	
Total	74,738,220				
	Departmental Afforestation for 5 year period reduced by 27,836,520 to allow for 15,988 acres of Pinus pinaster and wattle established by sowing.				
orrected Totals 920/21-1924/25	46,901,700	23,630,463	4,690,170*	659,460	75,881,793
1925/26	26,580,240	4,119,931		69,600	
26/27	27,217,080	3,844,486		53,940	
27/28	25,090,800	4,565,938		266,220	
28/29	22,386,840	3,806,386		466,320	
29/30	24,761,940	3,989,245		321,900	
Total	126,036,900				
	Departmental Afforestation for 5 year period reduced by 49,003,620 to allow for 28,163 acres of Pinus pinaster and wattle established by sowing.				
orrected Totals 925/26-1929/30	77,033,280	20,325,986	7,703,328*		106,240,574

1740 plants/acre

Note: Espacements during the decade were still very close and an espacement of 5' x 5' has been used to calculate plants raised for departmental afforestation.

* An allowance of 10% of corrected afforestation total has been made for blanking. Plants used for blanking not recorded separately until 1934/35.

102/.....

PLANTS RAISED BY DEPARTMENT OF FORESTRY 1930/31-1939/40

Year	Departmental Afforestation	Sale to Public and Gratis issue	Blanking	Regeneration (Soft wood only)	Total
30/31	17,638,170	3,227,774	1,763,817*	-	
31/32	23,263,460	3,469,156	2,326,346*	866,360	
32/33	22,443,080	3,293,237	2,244,308*	817,960	
33/34	19,453,170	3,414,269	1,945,317*	-	
34/35	18,279,470	4,148,734	1,691,000	605,000	
Total	101,077,350				

Departmental Afforestation for 5 year period reduced by 28,843,980 and 6,376,430 to allow for 23,838 acres of Pinus pinaster and wattle established by sowing, and 12,031 acres planted with eucalypts.

rrected Totals 30/31-1934/35					
	65,856,940	17,553,170	9,970,788	2,289,320	95,670,218
35/36	18,713,860	3,284,407	2,038,500	1,406,020	
36/37	18,001,170	4,954,464	2.146,000	1,560,900	
37/38	17,485,710	4,486,070	1,925,629	1,399,970	
38/39	18,419,830	4,981,576	1,885,085	1,410,860	
39/40	16,298,700	4,298,038	1,629,870*	1,217,260	
Total	88,919,270				

Departmental Afforestation for 5 year period reduced by 6,393,640 and 2,782,500 to allow for 5284 acres of Pinus pinaster and wattle established by sowing and 5250 acres planted with eucalypts.

rrected Totals 35/36-1939/40					
	79,743,130	22,004,555	9,625,084	6,995,010	118,367,779

Pines 1210)
Eucalypts 680) plants/acre.

Note: Espacement for most conifer species had increased to 6' x 6' during this decade while the eucalypts were being planted at 8' x 8'. This was the last decade in which sowing was important as an establishment technique for P. pin and wattle.

* Figures for blanking not recorded for these years. the average percentage of years recorded is 10% :- 10% of afforestation figure has been used.

103/.....

PLANTS RAISED BY DEPARTMENT OF FORESTRY: 1940/41-1949/50

Year	Departmental Afforestation	Sale to Public and Gratis Issue	Blanking	Regeneration (Softwoods only)	Total
940/41	3,804,840				
941/42	2,454,300				
942/43	1,572,480	23,500,000	2,226,155*	7,943,400	
943/44	1,299,780				
944/45	1,665,900				
Total	10,797,300				
	Departmental Afforestation for 5 year period reduced by 196560 to allow for 364 acres of wattle established by sowing.				
orrected Totals 940/41-1944/45	10,600,740	23,500,000	2,226,155	7,943,400	44,270,295
945/46	3,700,620	9,148,605	851,143	3,502,440	
946/47	5,146,740	8,907,470	1,213,000	2,661,660	
947/48	8,516,340	14,883,105	2,000,000	1,315,980	
948/49	9,802,620	13,612,004	2,255,000	1,601,100	
949/50	9,475,380	12,138,637	2,086,326	1,323,540	
Total	36,641,700				
	Departmental Afforestation for 5 year period reduced by 1,247,940 to allow for 2311 acres of wattle established by sowing.				
orrected Totals 945/46-1949/50	35,393,760	58,689,821	8,405,469	10,404,720	112,893,770

540 plants/acre

Note: The use of sowing as an establishment technique was abandoned except for wattle during this decade.

Espacements used for afforestation were 9' x 9' with the exception of a few poor quality sites established at 12' x 12'. The 9' x 9' espacement has been adopted throughout.

* Blanking allowance of 21% of afforestation figure has been used where actual number of plants used is not available. (Mean % for existing figures is 21.1%)

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PLANTS RAISED BY DEPARTMENT OF FORESTRY: 1950/51-1959/60

Year	Departmental Afforestation	Sale to Public and Gratis Issue	Blanking	Regeneration (Softwoods only)	Total
950/51	7,725,240	12,956,952	2,403,553	1,521,720	
951/52	9,867,960	14,372,567	2,095,713	1,540,980	
952/53	10,052,100	14,425,796	2,921,300	1,382,940	
953/54	11,816,820	20,330,713	2,699,156	2,043,900	
954/55	12,331,440	14,545,049	2,660,981	2,311,200	
Total	51,793,560				
	Departmental Afforestation for 5 year period reduced by 3,268,620 to allow for 6,053 acres of wattle established by sowing.				
orrected Totals 950/51-1954/55	48,524,940	76,631,077	12,780,703	8,800,740	146,737,460
955/56	10,839,420	14,943,000	2,344,000	2,663,280	
956/57	13,741,920	14,674,772	3,061,949	2,198,340	
957/58	14,458,500	17,030,825	3,800,974	2,948,400	
958/59	8,969,400	12,041,557	4,945,355	2,980,800	
959/60	10,247,580	11,151,966	5,034,811	1,084,320	
Total	58,256,820				
	Departmental Afforestation for 5 year period reduced by 1,143,180 to allow for 2,117 acres of wattle established by sowing.				
orrected Totals 955/56-1959/60	57,113,640	69,842,120	19,187,089	11,875,140	158,017,989

540 plants/acre

Note: The only species established by sowing during this decade was wattle. All espacements were 9' x 9' with two exceptions:

i) Pine plantations in Zululand were established at 7' x 7' to allow for pulp wood from the first thinnings. This practise was started in 1953 and dropped in 1956 when the material proved unsatisfactory for pulp.

ii) *Pinus canariensis* and other pine species established for pole production were planted at 6' x 6', but formed a negligable proportion of the whole.

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APPENDIX 3.

M.60000 & A.1010.

Sekretaris van Bosbou,
Posbus 334,
PRETORIA.

ALLE STREEKSHOOFDE.

BELEID: STAATSKWEKERYE.

1. Uit navrae wat van verskeie streke ontvang is blyk dat daar nog heelwat onsekerheid bestaan met betrekking tot die implementering van die ministeriële beleid insake die handelsbedrywighede van die departement, veral ten opsigte van die verkoop van sierbome, sierstruike en hegplante.

2. Teneinde meer helderheid te gee, word die volgende uiteensetting as algemene leidraad aangebied:-

   (i) Alle Staatskwekerye wat binne die grense van die digbevolkte blanke gebiede geleë is en waar die handelsbedrywighede van sulke kwekerye in direkte konkurensie met private ondernemings is, word gesluit.
   In hierdie Kategorie val die volgende:-
   Groenkloof, Bloemfontein, Retreat en Port Elizabeth.
   Al hierdie kwekerye is reeds gesluit. Die Streekshoof moet redes aanvoer waarom Cedara nie ook onder hierdie groep sorteer nie.

   (ii) Staatskwekerye wat in die onmiddellike omgewing van dorpe geleë is, maar waar private kwekerye nog nie tot die mate ontwikkel het dat hul in die behoeftes van sulke van die omliggende streke kan voorsien nie. Die summiere sluiting van hierdie kwekerye sal 'n lugleegte skep wat groot ongerief vir die algemene publiek kan meebring. Dit is egter noodsaaklik dat dit onder die aandag van die plaaslike publiek gebring sal word dat die departementele kwekerye sy handelsbedrywighede in sierbome en sierstruike wens te staak, sodra private inisiatief in die behoeftes kan voorsien. Waar daar plaaslike koerante in omloop is kan u dus die volgende inligting as 'n nuusberig aanbied:-

   "As gevolg van 'n kabinetsbesluit wil die Departement van Bosbou dit graag onder die aandag van die publiek bring dat hy van voornemens is om sy handelsbedrywighede in sierbome en sierstruike te staak sodra privaat kwekerye in die behoeftes kan voorsien. Die Staatskwekerye te sal hom, ooreenkomstig hierdie besluit derhalwe geleidelik onttrek aan die handel in hierdie tipe boom of struik, maar sal voortgaan om bome wat gewoonlik as skadubome of windbreke op plase gebruik word te kweek en aan boere te verskaf beide teen gesubsidieerde en teen normale ekonomiese pryse. Inheemse boomsoorte sal ook nog, soos in die verlede deur die Staatskwekery verskaf word".

   Die volgende Staatskwekerye sorteer in hierdie kategorie:-
   Grabouw, Kruisfontein, Witfontein, Dargle, Hangklip, Empangeni.

   (iii) Staatskwekerye op Bosreservate geleë en redelik ver van dorpe of stede. Hierdie kwekerye bedien gewoonlik 'n baie wye plattelandse gebied en die bestellings kom hoofsaaklik deur die pos. Die volgende kwekerye sorteer in hierdie groep:-

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Garcia, Kluitjieskraal, Witelsbos, Fort Cunyngham, Langsnek, Weza, Grenshoek, Bultfontein, Wilgeboom, Belfast, Holfontein, Imperanie, Lichtenburg en Umpilusi. Alhoewel die moontlikhede skraler is dat private kwekerye in die behoeftes sal kan voorsien, is die beleid natuurlik ook op hierdie kwekerye van toepassing, maar omdat hulle 'n baie wydverspreide gemeenskap bedien, sal hulle toegelaat word om 'n beperkte hoeveelheid sierbome en sierstruike vir departementele gebruik en vir lewering aan die plattelandse publiek te kweek.

3. Dit word nie van kwekerye in Groep (ii) & (iii) verwag om bestellings vir sierbome, sierstruike en hegplante afkomstig uit stedelike gebiede, uit te voer nie.

4. Dit is nie die departement se funksie om bome vir kommersiële aanplantings te kweek nie, maar indien daar aanvraag voor is en dit kan nie deur private kwekerye uitgevoer word nie, sal daar geen beswaar teen wees indien die Staatskwekery dit lewer nie. Alle verkopings aan die publike, met uitsondering van bome wat teen gesubsidieerde pryse aan bona fide boere verskaf word, sal teen ekonomiese pryse wees. Sodra die kosteberekeningstelsel glad funksioneer sal daar dus 'n algemene hersiening van tariewe moet wees.

5. Die Kwekerye te Imperani en Lichtenburg sal baie waarskynlik ook binnekort sluit.

(get.) D.R. de Wet.
SEKRETARIS VAN BOSBOU.

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APPENDIX 4.

Extract from Act No.42 of 1957.

CHAPTER I.

INSECT PESTS AND PLANT DISEASES.

NURSERIES.

Registration of nurseries and sale of plants therefrom.

2.(1) Every occupier of a nursery shall, unless exempted by the Minister, register annually that nursery with the department in a manner and at a time prescribed by regulation and shall pay annually in respect of such registration such fee as may be likewise prescribed.

(2) Unless exempted by the Minister, no person shall sell or otherwise dispose of any tree, shrub, vine, ornamental plant or fruit-bearing plant which was at any time in any nursery which was not registered in terms of this Act or not exempt from registration under sub-section (1), while such plant was therein.

(3) No person shall sell any tree, shrub, vine, ornamental plant or fruit-bearing plant unless his name and address are legibly and durably affixed to the plant or to the container in which it grows or is packed.

Inspection and quarantining of nurseries.

3. (1) Any officer may, at all reasonable times, enter upon any nursery or land adjacent thereto and inspect the same and the plants therein or thereon, and take such steps as may be necessary to determine whether or not any insect pest or plant disease is present.

(2) If, upon any such inspection, the officer finds any plant infected, or has reason to suspect that any plant is infected, with an insect pest or plant disease he may by post notice in writing, delivered or transmitted by post to the occupier, and to the magistrate of the district in which the nurseries is situate, declare the whole nursery, or any specified area thereof, to be quarantined for a definite or an indefinite period.

(3) No person shall, without a permit in writing from the department, remove or cause to be removed any plant from a quarantined area of a nursery: provided that a plant may, for the purpose of its destruction or treatment, be removed from any such quarantined area under such conditions or restrictions and to such place as the department or the officer may prescribe.

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(4) No person shall, without the permission of an officer, remove or otherwise interfere with any stake, peg, tag or other mark placed by or on the order of an officer in or near a quarantined area.

(5) If the person registered in respect of a nursery is charged with a contravention of sub-section (4) and it is proved that a stake, peg, tag or other mark has been removed or otherwise interfered with in contravention of the said sub-section, that person shall be deemed to have so removed or interfered with such stake, peg, tag or mark unless he proves to the satisfaction of the court that he forbade the act constituting the contravention.

Removal of quarantine.

4.(1) If any area of a nursery is quarantined under section three either for a definite or an indefinite period, the occupier may apply in writing to the department for the removal of the quarantine.

(2) The department shall, within six weeks after the date of the application, cause a further inspection to be made and, if it is deemed expedient, the quarantine may, subject to the provisions of sub-section (4), be removed by written notice, which shall be delivered or transmitted by post to the occupier and to the magistrate of the district in which the nursery is situate.

(3) In respect of any inspection of a nursery under this section the occupier shall pay such fee as is prescribed by regulation, together with the travelling and like expenses (if any) incurred by the department in carrying out that inspection.

(4) No quarantine shall be removed until the fees and expenses aforesaid have been paid.

Disinfecting of plants.

5.(1) Every occupier of a nursery shall, unless specially exempted by the department, provide and maintain in good order in his nursery, for the disinfecting of plants, such an airtight chamber as is prescribed by regulation.

(2) An officer may require any plant in the nursery before it is dispatched therefrom to be disinfected in such an airtight chamber in accordance with regulation or in such other manner as he may prescribed.

Destruction of plants infected with disease.

6. The Minister may destroy, or cause to be destroyed, or order the immediate destruction of -

(a) any plant which in a nursery is infected with any insect pest or plant disease deemed by him to be specially dangerous; or

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(b) any plant which is in a nursery and though not proved to be so infected, is in his opinion liable to have become so infected.

Compensation. 7.(1) Compensation shall be paid to the occupier of a nursery for any plant destroyed under paragraph (b) of section six, but not for any plant destroyed under paragraph (a) thereof.

(2) Compensation payable under sub-section (1) shall, if the occupier so requires, be assessed by two persons, one nominated by the department and the other by the occupier.

(3) If the persons so nominated fail to agree as to the amount of compensation to be awarded, they shall choose a competent umpire whose award shall be binding and conclusive.

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APPENDIX 5.

LIST OF STATE FOREST NURSERIES: REPUBLIC OF SOUTH AFRICA.

Name of Nursery.	Postal Address.	Railway station from where goods will be railed.
CAPE PROVINCE.		
K.1. Fort Cunynghame.	P.K. Döhne.	Döhne.
2. Garcia.	P.O. Box 87, Riversdale.	P.M.D. Novo.
3. Grabouw.	P.O. Box 41, Grabouw.	Elgin.
4. Kluitjieskraal.	P.O..Wolseley.	Wolseley.
5. Kruisfontein.	Private Bag, Kruisfontein.	Knysna.
6. Witelsbos.	P.O. Witelsbos.	P.M.D. Witelsbos.
7. Witfontein.	P.O. Box 7, George.	George.
NATAL.		
8. N.1. Cedara.	P.O. Cedara.	Cedara.
9. 2. Dargle.	P.O. Dargle.	Dargle.
10. 3. Empangeni.	P.O. Empangeni.	Empangeni.
11. 4. Weza.	P.O. Harding.	Harding.
TRANSVAAL.		
12. T.1. Belfast.	P.O. Box 44, Belfast.	Belfast.
13. 2. Bultfontein*	P.O. Witrivier.	Witrivier.
14. 3. Grenshoek.	P.O. Politsi.	Politsi.
15. 4. Hangklip.	P.O. Box 36, Louis Trichardt.	Louis Trichardt.
16. 5. Wilgeboom.	P.O. Graskop.	Graskop.
17. South African Bantu Trust Forest Nursery.	P.O. Box 7022, Pietermaritzburg.	Pietermartizburg.

* Bultfontein closed down as a commercial forest nursery in 1962/63.

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APPENDIX 6.

LIST OF PRIVATE REGISTERED NURSERIES RAISING TREES FOR COMMERCIAL FORESTRY IN THE REPUBLIC OF SOUTH AFRICA.

NATAL.

1. Apple Tree Flower Farm,	P.O. Box 20, Richmond, Natal.
2. "Clonmel" Forest Nursery, (B. Roe-Scott).	P.O. Eston, Natal.
3. Eldorado Nurseries,	P.O. Box 12, Wartburg, Natal.
4. Greytown Municipality,	P.O. Box 71, Greytown, Natal.
5. Hegelar, H.C.	P.O. 1307, Vryheid, Natal.
6. Kenville Nursery,	P.O. Hilton Road, Pietermaritzburg.
7. Redclyffe Nursery, (Seven Oaks district)	Lion Match Co., Box 918, Durban.
8. Mlambomanye Forest, Tree Nursery.	Magtenburg, Howick, Natal.
9. Simtree Nurseries,	P.O. Box 2262, Durban, Natal.
10. South Coast Saligna Nursery,	P.O. Kenterton, South Coast, Natal.
11. Springvale Forest, Tree Nursery.	P.O. Box 84, Greytown, Natal.
12. Welverdiend Bosbou-boomkwekery.	Posbus 27, Paulpietersburg, Natal.

TRANSVAAL.

13. Bill Carter's Nurseries,	P.O. Box 302, Hamawasha, Tzaneen, Tvl.
14. Ermelo Forest Nursery,	P.O. Box 198, Ermelo, Transvaal.
15. Hoffnung Forest Nursery,	P.O. Panbult, Wakkerstroom, Tvl.
16. Piet Retief. Kromrivier Nursery,	Lion Match Co. P.O. Box 918, Durban.
17. New Osloop Nursery, Piet Retief.	" " "
18. Woodmeere Nurseries,	Private Bag 5080, Pietersburg, Tvl.
19. Messrs. Rottcher's Nursery,	P.O. White River, Transvaal.

CAPE.

20. Munisipale kwekery, Beltana.	Posbus 17, Stellenbosch.

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APPENDIX 7

CONIFEROUS CLEARFELLINGS: ESTIMATED AREAS FOR 5-YEARLY PERIODS, 1960-2000

(in acres)

Period	Total: Republic		FORESTRY REGIONS																	
			Western Cape		Midlands		Eastern Cape		Transkei		Natal		Zululand		Southern Tvl. + O.F.S.		Eastern Transvaal		Northern Transvaal	
	S	P	S	P	S	P	S	P	S	P	S	P	S	P	S	P	S	P	S	P
1960-65	25,741	8,929	3,639	160	9,642	1,867	3,644	17		143	3,254	2,103	487	64		254	3,330	1,071	1,745	3,250
1965-70	31,798	30,466	3,534	495	10,658	4,778	3,724	34	756	144	3,319	7,034	1,302	206	930	4,817	5,184	8,087	2,391	4,871
1970-75	47,124	83,948	4,686	2,316	11,268	7,123	3,572	32	2,171	47	3,585	7,705	2,295	5,021	4,501	25,124	12,125	31,725	2,921	4,855
1975-80	52,418	105,749	4,370	4,442	11,207	15,491	3,665	540	3,007	48	4,053	22,239	3,122	1,407	5,626	26,988	14,295	29,558	3,173	5,036
1980-85	68,419	113,011	4,723	6,001	13,514	13,545	3,910	870	6,957	14	5,719	18,600	4,092	1,794	5,765	39,312	18,867	25,377	4,872	7,498
1985-90	80,733	81,541	4,499	1,666	11,344	7,173	3,854	807	6,970	127	9,872	10,814	13,314	1,424	6,122	42,366	19,798	9,554	4,960	7,610
1990-95	81,953	48,986	4,606	2,646	12,087	4,778	4,094	234	6,970	297	9,848	10,290	13,247	576	7,040	10,209	18,930	14,628	5,131	5,328
1995-2000	83,603	90,506	4,697	4,815	9,229	7,123	3822	32	6,970	9	9,841	7,895	13,242	4,633	8,370	28,291	19,883	32,205	7,549	5,503

Reference: S. - State

P. - Private

APPENDIX 8

PLANNED FUTURE AFFORESTATION (IN ACRES)

Forestry Region	Ownership	1960 - 65			1965 - 1970					
		Conifers	Broadleaved	Total	Conifers	Broadleaved	Total	Conifers	Broadleaved	Total
Total: Republic	T	180,150	73,849	253,999	159,314	17,659	176,973	180,198	10,693	190,891
	S	106,025	3,020	109,045	136,797	1,668	138,465	163,430	-	163,430
	P	74,125	70,829	144,954	22,517	15,991	38,508	16,768	10,693	27,461
Western Cape	T	4,301	-	4,301	5,646	-	5,646	9,648	-	9,648
	S	2,748	-	2,748	3,800	-	3,800	5,360	-	5,360
	P	1,553	-	1,553	1,846	-	1,846	4,288	-	4,288
Midlands	T	12,936	240	13,176	9,387	-	9,387	-	-	-
	S	8,030	-	8,030	9,387	-	9,387	-	-	-
	P	4,906	240	5,146	-	-	-	-	-	-
Eastern Cape	T	4,202	-	4,202	1,522	-	1,522	-	-	-
	S	3,877	-	3,877	1,272	-	1,272	-	-	-
	P	325	-	325	250	-	250	-	-	-
Transkei	T	8,538	2,252	10,790	13,990	1,020	15,010	10,000	758	10,758
	S	8,500	2,020	10,520	13,700	580	14,280	10,000	-	10,000
	P	38	232	270	290	440	730	-	758.	758
Natal	T	24,982	22,731	47,713	7,976	2,847	10,823	2,052	1,903	3,955
	S	15,290	-	15,290	3,557	88	3,645	-	-	-
	P	9,692	22,731	32,423	4,419	2,759	7,178	2,052	1,903	3,955
Zululand	T	47,420	2,065	49,485	85,420	3,486	88,906	138,000	125	138,125
	S	46,000	-	46,000	85,000	-	85,000	138,000	-	138,000
	P	1,420	2,065	3,485	420	3,486	3,906	-	125	125
Southern Tvl. and O.F.S.	T	49,939	25,126	75,065	12,924	5,156	18,080	11,526	-	11,526
	S	7,616	-	7,616	6,460	-	6,460	4,600	-	4,600
	P	42,323	25,126	67,449	5,464	5,156	11,620	6,926	-	6,926
Eastern Transvaal	T	18,578	7,939	26,517	18,242	3,253	21,495	6,652	6,462	13,114
	S	9,203	1,000	10,203	10,377	1,000	11,377	4,000	-	4,000
	P	9,375	6,939	16,314	7,865	2,253	10,118	2,652	6,462	9,114
Northern Transvaal	T	9,254	13,496	22,750	4,207	1,897	6,104	2,320	1,445	3,765
	S	4,761	-	4,761	3,244	-	3,244	1,470	-	1,470
	P	4,493	13,496	17,989	963	1,897	2,860	850	1,445	2,295

Reference: T - Total
S - State
P - Private

APPENDIX 9.

A STUDY OF MANUAL WATERING: ELGIN FOREST NURSERY, CAPE.

The nursery stock in the Forest Department nursery at Elgin in the Western Cape is raised in trays. These are laid out in beds four trays wide, without fixed length. Watering is done by native labour using watering cans on which the rose has been replaced by a flat sheet of metal to allow for faster and broader flow. Watering is usually required from November to April and occasionally longer. The nursery raises about a million to a million and a quarter plants annually, of which most are Pinus radiata. Watering is expensive at this nursery accounting for 23% of the total costs. It is done under constant supervision in a manner which has been found satisfactory.

After a very hot weekend in the early summer of 1961, a number of trees in the outer trays of many of the beds were dying while trees in the inner pair of trays remained healthy and of good colour. No sign of any pathogen was found and it was concluded that the trees had died of drought following the high temperatures of the previous weekend. The complete survival of the trees in the two inner trays was puzzling, however. Was it due to additional protection, preventing evaporation, or to uneven watering? To test this, twelve files, each of four trays, were selected at random throughout the nursery. Each tray was weighed immediately before watering and again immediately after watering on an Avery platform scale. The watering carried out was the standard operation, the labour not being told of the study, or its purpose. Six files were measured on the 7th December 1961 and six on the 21st December 1961. The results obtained are given below.

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ANALYSIS OF VARIANCE.

Difference in weight before and after watering (in ounces).

Source of Variation.	D.F.	S.S.	M.S.	F.
Replicates.	11	3553.5	323.05	11.237**
Tray position.	1	416.7	416.70	14.494**
Error.	11	316.3	28.75	-
Total.	23	4286.5	-	-

SUMMARY OF ANALYSIS.

	Inner Position.	Outer Position.	Mean	S.E.	P.values .05	.01
Water received by 2 trays.	33.4	25.0	29.2	1.5	4.8	6.8
Water received by single tray.	16.7	12.5	14.6	-	-	-

The inner trays get appreciably more water than the outer trays of a four tray bed. There is considerable variation in the amount of water that any tray gets. The lowest recorded was 3 ozs., while the highest was 36 ozs. per tray.

The mean weight of water received by the trays weighed is 14.6 ounces, sufficient to cope with evaporation and transpiration on a warm summer's day. Evaporation losses on a warm summer day from a nursery tray full of soil at field capacity but without plants, is 18 ounces. Losses from a box with plants are lower, as the transpiration losses are amply compensated by decreased evaporation from the shaded soil.

To supply the requirements of the plants just under 1 pound of water is required daily, if appreciably more is given there is danger of excessive leaching of available minerals while if appreciably less is given the growth potential of the plant is reduced.

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It must be stressed that the watering operation at Elgin appears completely uniform. Supervision is constant and strict. When the data of the 7th December had been analysed the foreman was advised and supervision, if possible, was increased. On the 21st the operation again appeared completely uniform but the results from the weighings were the same. It is exceedingly doubtful if any appreciable improvement in uniformity can be obtained from manual watering.

The only reliable method of improving the watering of a nursery of this size is to install automatic sprinklers. Not only is the water then applied at a uniform level but the very considerable savings in labour force would pay for the capital expenditure involved within the first season of installation.

Conclusions.

1. Manual watering of a forest nursery using watering cans is unsatisfactory, the inner pair of trays of a four tray bed get roughly ½ as much water as the outer pair and variation from one tray to the next is considerable.
2. The installation of an automatic sprinkler system is recommended to improve the uniformity of watering and to reduce the cost thereof.

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APPENDIX 10.

AN EXPERIMENT TO TEST THE EFFECT OF VARIOUS PREPLANTING TREATMENTS ON PERCENTAGE SURVIVAL AND SUBSEQUENT GROWTH OF OPEN-ROOTED PLANTING STOCK OF THE PINE SPECIES RAISED FOR COMMERCIAL AFFORESTATION IN THE CAPE MIDLANDS.

An experiment was commenced in April 1957, to raise open-rooted planting stock of the four common pine species raised in the Midlands Conservancy of the Cape, Pinus radiata, Pinus taeda, Pinus elliottii and Pinus pinaster.

The objects of the experiment were:-

(i) to compare plants raised from seed direct sown at a given espacement in nursery beds to plants raised from densely sown seed pricked out after it had attained a suitable size;

(ii) to compare different methods of treating the stock after it had been lifted to find the most effective method of preserving open-rooted planting stock;

(iii) to compare two different packing materials for transporting open-rooted planting material.

The variables can be summarised as follows:

A. Method of Raising (2)
- (i) Direct sown at a given espacement.
- (ii) Densely sown and pricked out at a given espacement.

B. Prepacking Treatment (4)
- (i) No further treatment after lifting.
- (ii) Lifted, the roots soaked 10 minutes in water.
- (iii) Lifted, and the roots dipped in puddled clay.
- (iv) Sprayed with V.L. 600 + T.B. 1956 and allowed to dry before lifting.

C. Packing material used (2)
- (i) Packed in wet sacking.
- (ii) Packed in large plastic bags.

All plants were raised in Kruisfontein forest nursery near Knysna. The beds used were 3' x 12' with a depth of 4". Each bed was contained within a wooden frame, the under side of which was planed to facilitate root pruning by piano wire. Situ sown seed and pricked out plants were placed at an espacement of 2" x 2" giving a possible 1224 plants per bed.

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Seed of all four species were sown, either thick or in situ, between the 2nd and the 8th of May 1957. Seed was thoroughly mixed and split into two approximately equal lots, half being sown thickly and half situ sown. The following table gives details of the seed used and plants obtained there from.

		Situ Sown.			Pricked Out.		
Species.	No.of Seed p/lb.	Wt.of Seed Sown	No.of use-able plants raised	Plant %	Wt.of Seed p/sown	No.of use-able plants raised	Plant %
P.radiata	18,000	6½ ozs	5088	69	8.ozs	4720	52
P.pinaster	10,000	11½ ozs	6092	83	8 ozs	1980	40
P.taeda	19,500	6 ozs	4454	61	8 ozs	5615	58
P.elliottii			All Failed!				

Pricking out of P.radiata and P.pinaster was completed during July. Germination of P.taeda was slow and spasmodic and pricking out was not done until August 1957. The seed of P.elliottii was exceptionally poor and this species was dropped for the remainder of the experiment.

Root pruning was carried out by means of piano cable wire, 220 lbs. breaking strain, attached to two spade handles. The wire was pulled under the bed manually. The bed length of twelve feet was sufficiently short to allow a complete pruning without any additional cleaning of the wire. Beds were thoroughly soaked after root pruning but not before, as it was found that the roots tended to be pulled by the wire instead of cut if beds were soaked before pruning.

Pruning was first carried out in July for situ sown P.radiata and P.pinaster, and in August one month after transplanting, for the pricked out stock. P.taeda was pricked out during August 1957 when the situ sown stock received its first root pruning. Pricked out P.taeda was also root pruned one month after pricking out.

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Root pruning was carried out once a month from when it commenced, until the plants were lifted for planting. This took place in May 1958 for the P.radiata, in October 1958 for P.taeda and in November 1958 for P.pinaster. The number of root prunings varying from 10 and 11 for P.radiata to 14 and 15 for P.pinaster. At time of lifting all plants were root pruned, soaked and then lifted from the beds. All soil was shaken from the roots and the plants were counted into bundles of 132 - the number required for each ¼ acre plot. Lateral roots in all cases were found to be too long and were trimmed to approximately 6" with a sharp knife once the plants had been lifted and shaken out. Plants were culled on lifting, all damaged, undersized or diseased stock being discarded.

All prepacking treatments, with the exception of the V.L. 600 spray, were applied to the stock after it had been lifted and bundled. The V.L. 600 treatment was applied as a foliar spray and allowed to dry before the plants were lifted.

For the packing section of the experiment large plastic wardrobe bags and 200 lb. grain sacks were used.

The total number of treatments for each species was sixteen. Lay out being a randomised block with three replications. Each species is dealt with separately as each was planted in a different district and formed a separate section to the experiment.

P.radiata. These plants were lifted in May 1958, just over one year after sowing. When the various treatments had been applied the plants, 6,400 in all, were loaded into a ¾ ton truck and left untouched for two days. After this time the plants were driven to the planting site in Kruisfontein plantation (Compt. A 3j). All plants were trenched on arrival at the planting site, plants being withdrawn from the trench as required for planting.

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Planting was done by spade using a T notch in prepared pits. Each labourer was given a small plastic bag (12" x 18") to carry his plants in, during the planting operation.

Weather. The weather during the initial lifting was bright and sunny with little or no wind. Temperature during the spraying of the V.L. 600 was 64°F. Light rains fell on the evening of the following day and the ground was in good order for planting. During planting, on the third day after lifting, it was bright with a cold light westerly wind. This wind quickly dried the roots of any palnts not protected.

Site Details. The planting site for this experiment lies in a small Y shaped valley of Compt. A 3j Kruisfontein. Block I was on a medium slope with a northerly aspect, Block II medium to steep slope, aspect ENE to E., Block III medium slope, aspect south. It originally carried a mixed Eucalyptus resinifera, Eucalyptus pilularis and Acacia melanoxylon stand which was clear felled in 1957. Coppice regrowth which was profuse was slashed in April 1958 and burnt early in May 1958, about one week before planting. The soil varies very little between and within blocks, indeed the A horizons were the same colour and texture throughout the compartment. The following profile description notes were taken from Block II and will serve for the whole area.

A_o	1"	Humus, debris of Eucalyptus species.
A_1	15"	Grey brown clayey sandy loam, texture the same as for pits I & III.
B_1	22"	Yellow clayey sand, soft and moist.
B_2	at least 22"	Reddish brown sandy clay with numerous iron deposits in top inch of horizon. These latter are not indurated and do not impede root penetration.
		Roots to bottom of 5' pit.

Percentage survival and height of the surviving plants was measured during November 1959, six months after planting. The data has been analysed and the results are given in the following tables.

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1.a.ANALYSIS OF VARIANCE.(% death 6 months after planting).

Component of Variation.	D.F.	S.S.	M.S.	F.
BLOCKS	2	130.67	65.335	3.92*
Method of Raising	1	477.57	477.57	28.63**
Prepacking treatment	3	383.61	127.87	7.67**
Type of Packing material	1	0.20	0.20	.01 N.S.
Raising x Prepacking	3	237.13	79.04	4.74**
Raising x Type of Packing	1	29.74	29.74	1.86 N.S.
Prepacking x type of Packing	3	45.67	15.22	.91 N.S.
Raising x Prepacking x Type of Packing.	3	36.05	12.02	.72 N.S.
Total Treatment.	15	1209.97	80.66	4.84**
Error.	30	500.38	16.68	-
TOTAL.	47	1841.02	16.68	-

1.b.SUMMARY OF ANALYSIS (% Death).

	No Treatment	Dipped in water	Dipped in clay	Sparyed V.L.600	Means
Situ Sown	3.8	2.7	7.6	2.1	4.1
Pricked Out	16.0	11.5	10.6	3.2	10.3
Means	9.9	7.1	9.1	2.7	7.2

	Standard Error	Significant P = 01	Difference P = 05
Method of Raising	.83	3.2	2.4
Prepacking Treatment	1.18	4.6	3.4
Body of Table	1.67	6.5	4.8

2.a. ANALYSIS OF VARIANCE (Average height six months after planting)

S of V	D.F.	S.S.	M.S.	F.
BLOCKS	2	2.41	1.21	3.433 N.S.
Method of Raising	1	103.25	103.25	294.160**
Prepacking Treatment	3	21.40	7.13	20.313**
Type of Packing Material	1	.07	.07	1 N.S.
Raising x Prepacking	3	22.79	7.60	21.652**
Raising x Type of Packing	1	3.41	3.41	9.715**
Prepacking x Type of Packing	3	.20	.06	1 N.S.
Raising x Prepacking x Type of Packing	3	1.14	.38	1.083 N.S.
Total Treatment.	15	152.26	10.15	28.917**
Error.	30	10.54	.35	-
TOTAL.	47	165.21	-	-

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2.b. SUMMARY OF ANALYSIS (Average height 6 months after planting)

	No Treatment	Dipped in water	Dipped in clay	Sprayed V.L.600	Means
Situ Sown	10.5	10.9	10.4	10.1	10.5
Pricked Out	5.4	8.3	7.4	9.0	7.5
Means.	8.0	9.6	8.9	9.5	9.0

	Standard Error	Significant P = 01	Differences P = 05
Method of Raising	.121	.47	.24
Prepacking Treatment	.171	.66	.35
Body of table	.242	.94	.49

	Wet Sacks	Plastic Bags	Means
Situ Sown	10.2	10.8	10.5
Pricked Out	7.8	7.3	7.5
Means.	9.0	9.0	9.0

	Standard Error	Significant P = 01	Differences P = 05
Method of Raising	.121	.47	.24
Type of Packing	.121	.47	.24
Body of table	.171	.66	.35

The survival of P.radiata planting stock raised in beds and planted open-rooted is significantly affected by the method of raising the material. The situ sown stock was 4" larger and had a thicker collar diameter (6.5 mm.) than the pricked out stock (6" and 3.5 mm.) The root systems of both types were perfectly suitable for open-rooted planting being devoid of tap root and having a well developed, fiberous, lateral root system. The only difference in the plants raised by the two methods is in size. Particular care had been taken with the pricking out of the pricked out stock to avoid the distorted roots said to be associated with poor survival. Roots of either type seriously damaged during lifting were culled after lifting.

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The larger sturdier plant is apparently better suited to withstand the shock and subsequent desiccation until the root system again begins to function. The effect of the V.L.600 foliar spray on the percentage survival of pricked out stock is very striking. The other prepacking treatments also have a significant effect on the percentage survival of the pricked out stock but not so marked as that of V.L.600. Prepacking treatments have little significant effect on the percentage survival of Situ sown stock except for the adverse effect of the clay dipping, significant at the 5% level. This last is an unexpected result as clay dipping is of proven value with several coniferous species.

The initial growth of the pricked-out plants is significantly improved by the three prepacking treatments tried, though again the V.L.600 gives the most effective response. Situ sown stock is not appreciably affected by the prepacking treatment.

A significant interaction between method of raising and type or packing was recorded. Situ sown plants giving better growth when packed in plastic while the pricked out stock do best from sack packing. It is only the interaction which is significant not the method of packing itself and it is significant only for initial growth, not for percentage survival. The reasons for this interaction are as yet unexplained, and are probably only applicable to this experiment.

The plastic coating used in this experiment is sold under the trade name of Goodrite Latex V.L. 600. South African distributors are Fisons Pest Control (S.A.) Ltd. Goodrite Latex V.L. 600 is a stable colloidal dispersion of a modified vinyl resin in water. It is supplied in concentrated form and is diluted 1 in 4 with water. It is a milk white liquid which dries at room temperature to give a colourless film. It is best used in conjunction with a sticker, in this case Trition B 1956 was used. One pint of concentrate costing 95 cents was

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sufficient to coat 2000 plants. The use of the plastic as a root dip had previously been shown to be detrimental to survival, as the period of exposure required to dry the plastic allowed considerable desiccation of the roots to occur. (appendix 12).

The cost of this treatment is high, just under 50 cents per 1000 trees or roughly 25 cents per acre including cost of application, but is appreciably cheaper than the blanking operation which is required for all other treatments of the pricked out stock.

This experiment was again enumerated in 1961, three years after planting. At this time the effect of the blocks had become highly significant while of the treatments only the method of raising was still significant. The following table gives the mean number of deaths and average height for the blocks and methods of raising.

	Block I aspect northerly	Block II aspect E.N.E.	Block III aspect South.	Situ Sown.	Pricked Out
No.of Deaths	22.0 (16.7%)	12.0 (9.1%)	5.9 (4.5%)	10.0 (7.6%)	16.6 (12.6%)
Average height.	5.2'	5.6'	6.9'	6.4'	5.4'

	Deaths		Average Height	
S.E. blocks.	2.161		.268	
S.E. values Method of Raising	1.765		.219	
	P.05	P.01	P.05	P.01
P.values Blocks.	6.2	9.4	0.8	1.0
P.values Method of Raising	5.1	6.9	0.6	0.9

The following conclusions have been drawn from this section of the experiment:

1. Planting stock of P.radiata raised from direct sowing in beds has a significantly better percentage survival than pricked out stock. The difference is thought to be entirely due to the size and sturdiness of the former

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material. A 10 to 12 inch plant with a collar diameter of 6.5 mm. and an R.S. ratio of .60 is recommended as the most satisfactory size for this species for open-rooted planting.

2. The plastic coating material, V.L.600 applied as a foliar spray has a significant and beneficial effect on the percentage survival of pricked out stock. It is recommended where plants of six inches or less are to be planted open-rooted. The cost of the treatment, approximately 50 cents per 1000 plants, is fully recovered by the increased survival of the planting stock. Resumption of growth is also beneficially influenced by this treatment being faster than all others tried at the 5% significance level.

3. The various prepacking treatments tried have had no significant beneficial effect on the percentage survival or commencement of growth for the larger situ sown stock.

4. Either wet sacking or plastic bags can be used for the protection of open-rooted Pinus radiata transplants in transit from the nursery to the field. Percentage survival after planting was not significantly affected by the 48 hour period the plants were in transit.

5. The effect of aspect on percentage survival and growth of open-rooted Pinus radiata is marked, Northern aspects giving significantly inferior results to Southern and Eastern aspects.

P.taeda.

The lifting and planting of this species was carried out in the same way as for Pinus radiata. Lifting was begun at Kruisfontein on the 6th of October 1958. When the plants had been treated they were placed on the ¾ ton truck, and left until the 8th of October, on which date they were transported

just under one hundred miles and planted on Lottering Forest Reserve in the Tsitsikama Forest District.

On this occasion plants were not trenched but were handed out from their packings on the truck. Planting was again by spade into prepared pits using a T notch. Plastic bags were used to protect plants during the planting operation.

Weather.

During the initial lifting at Kruisfontein nursery on the 6th of October the weather was cloudless bright and sunny with a moderate South Easterly wind. Temperature at 10 am. when lifting commenced was 82°F. becoming warmer during the morning and reaching a maximum of 90°F. at half past two. Temperature at time of spraying with V.L. 600 was 84°F.

On the 7th the weather became cloudy with a falling barometer, forecasting rain. On the 8th, the day of planting, weather was very cloudy with a high humidity. A moderate South Westerly wind was blowing and temperatures were appreciably lower than on the 6th ranging from 52°F. when planting started to 60°F. during mid-afternoon. Intermitent rain fell during the evening of the 8th.

Site Details.

The planting site for this experiment lies between the old road and the National road just east of the Lottering Forest Station. The site is level, and carried old dense fynbos which was flattened and burnt before pitting and planting. Soil pits were dug in each of the three blocks. Soil profiles were similar over the whole area, the profile description being given for the middle block only.

A_1	3"	Loose friable black loam.
A_3	15"	Dark brown loamy clay, moist with numerous roots.
B_1	6"	Yellowish brown clay, moist, softer than A_3.
B_2	?	Heavy yellow clay, moist, no roots. Iron pan developing at two levels. Weakly at 6" from beginning of this horizon (2' 6" from surface) and again 12" below this (3' 6" from surface). This latter is more or less continuous and in places over ¼" thick.

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Survival was enumerated in March 1959 six months after planting. The percentage death was calculated and the results analysed. It was found necessary to transform the data for this experiment, an x transformation being used. None of the differences between treatments in the Pinus taeda planting experiment are significant, using the transformed data - though they had been using untransformed data. The trends for the four prepacking methods are similar to those for Pinus radiata, however, and are given below.

Percentage death of four prepacking treatments on P.taeda planting Stock. (Difference not significant).

No Treatment.	Dipped in water	Dipped in clay	Sprayed with V.L.600
12.4	10.9	7.3	7.0

The average survival for the whole 12 acre experiment was 90.0% still satisfactory though lower than in the case of the P.radiata experiment where an overall percentage survival of 92.8% was recorded. The use of a clay dip with P.taeda open-rooted planting stock seems to be worth the very limited additional expense involved, despite the non-significance of the treatment data. Slocum & Maki (1956) have recorded a highly significant beneficial response to clay dipping for this species both for percentage survival and resumption of growth!

Conclusions.

1. Clay dipping with P.taeda open-rooted plants is recommended.
2. Although the Situ sown stock were larger and sturdier than the pricked out material size difference were not so great as for Pinus radiata and no significant difference for percentage survival were recorded.

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Pinus pinaster.

Plants were lifted at Kruisfontein on the 11th of November and transported to Pine Grove near Mossel Bay for planting on the 12th. Treatments were the same as those applied to the other pines previously described.

Site Notes.

The area lies on the Southern side of the Outeniqua range at an altitude of 1500 to 1600 feet. The site is divided in two by a small stream. Blocks I and II being on the west side and Block III on the east. Slope is medium and aspect southerly on Block I, steep and easterly on Block II and steep and westerly on Block III.

Soil depth varies considerably between blocks but not greatly within blocks. Block I has very shallow soil while Block III has an excellent profile and could easily have carried a more exacting pine than P.pinaster. Soil on Block II is intermediate between these two.

Soil profile taken in Block I.

Litter burnt, no Ao horizon. Mineral soil exposed.

A	6"	Dark brown loam with numerous small quartz and sandstone pebbles.
B	24"	Loose detritus of T.M.S. quartzite with small amount of soil intermixed.
C		T.M.S. quartzite.

Rock outcrops are frequent and soil depth poor.

Soil profile taken in Block III.

Litter burnt, no Ao horizon. Mineral soil exposed.

A	6"	Greyish brown sandy loam, roots numerous.
B_1	22"	Reddish brown loam with dark brown mottlings from humic deposits. Earth-worms very numerous in lower portion of this horizon. No stones, a few small pebbles.
B_2	18"	Light fawn coloured clayey sand with numerous small stones, all iron coated giving speckled appearance. Moist, few roots.
C		T.M.S. detritus.

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The area had never been planted before. Vegetation before burning was typical serial fynbos which has been burnt periodically. Bracken (Pteridium aquilinum) was the dominant vegetation over large areas of Blocks II and III at time of planting.

Weather.

A bright sunny cloudless day on the 11th when the plants were lifted with a light breeze from the N.E. Temperatures varied from 85°F in the morning to 96°F in the afternoon when V.L.600 was applied. During planting on the 12th the weather was overcast with a light westerly breeze. Intermittent showers fell throughout the day with heavy rain from 12.30 pm. to 1.40 pm. The 13th, when planting was finished, was a bright sunny day with little wind, becoming partially overcast in the late afternoon.

Six months after planting the experiment was enumerated for percentage survival. The mean percentage survival for the whole experiment was 4.5%. Neither treatments nor blocks had any significant effect on the percentage survival.

Conclusions.

1. Although weather conditions were quite favourable at time of planting, indeed normal tray plantings were still in progress when the experiment was laid out, the complete failure of the 6,400 plants over the 12 acres of this experiment show that planting was too late in the season for adequate survival of open-rooted P.pinaster.

Pinus elliottii.

No information of a positive nature can be drawn from the experiment for this species, but it is an excellent example of the value of seed testing before nursery sowings are commenced. Had such tests been carried out a considerable amount of fruitless labour and wasted nursery space could have been saved.

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General Remarks.

The appreciable increase in the plant percent for situ sown as opposed to pricked_out stock and the increased growth rate of the former method, give an excellent indication of the value of direct sowing for raising nursery stock for the open-rooted planting method, provided germinative capacity is high and germination not unduly prolonged. Both of these factors can be determined accurately by seed testing before sowings.

References.

Slocum, G.K. & Maki, T.E. 1956: Journ. of Forestry 54:5-313-315. "Exposure of Loblolly Pine Planting Stock".

APPENDIX 11.

NOTES ON A PINUS ELLIOTTII AND PINUS PINASTER EXPERIMENT: COMPARTMENTS 8 AND 13 FARLEIGH FOREST RESERVE, CAPE.

A planting experiment to compare open-rooted and tray plants was laid out during August 1956. Three different planting methods were tried for each type of stock. The treatments used are given below.

A. Type of Stock (2) i) Normal plants in trays.
ii) Open-rooted plants, lifted and shaken out from nursery trays.

B. Method of Planting.
(3) i) Trowel planting in prepared pits.
ii) Trowel planting without prior pitting.
iii) Spade planting without prior pitting.

After the plants had been planted four months, an enumeration of the percentage survival was carried out. At this time a large number of the Pinus elliottii plants although alive and growing had been badly eaten by buck and vole, these plants were taken as having survived for the purposes of this experiment.

The results have been analysed and are given below.

P.elliottii.

Analysis of Variance (% Survival).

S. of V.	D.F.	S.S.	M.S.	F.
Blocks	5	216.83	43.376	1 N.S.
Type of Stock	1	3173.44	3173.44	51.47**
Method of Planting.	2	2547.45	1273.725	20.66**
T.S. x M.P.	2	849.41	424.705	6.89**
Error	25	1541.39	61.656	-
TOTAL	35	8328.57	-	-

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SUMMARY OF ANALYSIS (% Survival).

	Pit planted	Trowel without prior pitting.	Spade without prior pitting	Means
Boxed	97.1	87.9	91.1	92.0
Open-rooted.	91.8	64.6	63.2	73.2
Means	94.5	76.2	77.1	82.6

		Significant Difference P = 05	P = 01
S.E. Body of table	= 3.025	8.8	11.9
S.E. Type of Stock	= 1.86	5.4	7.3
S.E. Method of Planting	= 2.27	6.6	8.9

P.pinaster.

ANALYSIS OF VARIANCE (% Survival).

S. of V.	D.F.	S.S.	M.S.	F.
Blocks	5	2625.81	525.162	4.958**
Type of Stock	2	12757.70	12757.700	120.450**
Method of Planting.	1	2785.82	1392.910	13.151**
T.S. x M.P.	2	243.85	121.925	1.151 N.S.
Error	25	2647.93	105.917	-
TOTAL.	35	21061.11	-	-

SUMMARY OF ANALYSIS (%Survival).

	Pit planted	Trowel without prior pitting	Spade without prior pitting	Means
Boxed	94.4	74.7	77.5	82.2
Open-rooted	54.9	31.8	46.9	44.5
Means.	74.65	53.25	62.2	63.4

		Significant Difference P =05	P = 01
S.E. Body of Table	= 4.201	12.2	16.6
S.E. Type of Stock.	= 2.426	8.7	11.7
S.E. Method of Planting	= 2.971	7.1	9.6

Site heterogenity, combined with severe weed growth, damage by voles and considerable natural regeneration have brought about the abandonment of the experiment before the

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crop has been established. The results are therefore of only limited value.

The following figures give the cost of planting per 1000 trees. The costs exclude nursery costs, supervision and those operations of site preparation which were common to all treatments, and are therefore intended for comparison only.

Differences in the costs of the same methods for the two species are due mainly to site difference, and also to the fact that the ground was drier for the Pinus pinaster and therefore more difficult to plant where pits had not previously been prepared.

P.elliottii.

Method of Planting.	Including.	Cost per 1000 trees.
A. Normal tray plants planted with trowels into prepared pits.	Loading, transporting, off loading, pitting and planting.	= 7.458 units.
B. Normal tray plants planted with trowels without prior pitting.	As for A but excluding pitting.	= 3.292 units.
C. Normal tray plants planted with spade without prior pitting.	As for A but without pitting.	= 2.976 units.
D. Open-rooted plants planted with trowel into prepared pits.	Lifting, transporting, loading and off loading, pitting and planting.	= 7.231 units.
E. Open-rooted plants planted with trowel without prior pitting.	As for D but without pitting.	= 2.004 units.
F. Open-rooted plants planted with spade without prior pitting.	As for D but without pitting.	= 2.114 units.

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P.pinaster.

Method of Planting.	Including.	Cost per 1000 trees.
A. Normal tray plants planted with trowels into prepared pits.	Loading, transporting, off loading, pitting and planting.	= 7.791 units.
B. Normal tray plants planted with trowels without prior pitting.	As for A but without pitting.	= 4.325 units.
C. Normal tray plants planted with spade without prior pitting.	As for A but without pitting.	= 4.285 units.
D. Open-rooted plants planted with trowel into prepared pits.	Lifting, loading and off loading, pitting and planting.	= 7.987 units.
E. Open-rooted plants planted with trowel without prior pitting.	As for D but excluding pitting.	= 4.848 units.
F. Open-rooted plants planted with spade without prior pitting.	As for D but excluding pitting.	= 5.521 units.

(For approximate per acre figures divide by 2).

Weather conditions were unfavourable when planting commenced and grew steadily drier during the period of lay-out. Thus while fairly reasonable for the P.elliottii the soil was dry for P.pinaster planting.

Rainfall for June, July and August was .477", .650" and 1.236" respectively. The dry period which commenced during the lay-out of the P.elliottii block was not properly broken for more than two weeks after the planting of P.pinaster had been completed.

Under unfavourable conditions open-rooted P.pinaster is clearly less hardy than closed-rooted stock. P.elliottii, however, can be used open-rooted with more confidence provided it is planted in prepared pits.

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The difference between the percentage survival of the two species in this experiment is thought to be due more to the deterioration in the planting conditions although the inherent hardiness of the two species is known to differ.

The costs of the different planting methods are of interest in that they show the cost of lifting of open-rooted plants to be approximately equivalent to the transport of nursery trays over short distances - in this case just under six miles.

It would therefore only pay to lift trees from nursery boxes if planting conditions are favourable and if the distance to the planting site is considerable.

The success of method D with P.elliottii is of interest. Costs of methods A and D are about the same in this experiment but if the open-rooted planting stock is raised in beds then method D should compare much more favourably with method A as nursery costs would be considerably reduced.

The cost of pitting accounts for a very high proportion of the costs in methods A and D. In the case of Pinus elliottii percentage survival of nursery tray stock would appear to be satisfactory without pitting, especially with spade planting (method C.). Pitting could profitably be omitted on many sites where it is at present carried out especially on areas which are being reafforested after clear-felling and burning. Pits will, however, continue to justify their existance in most new afforestation work and in those areas where vole damage and vigorous natural vegetation are likely to be troublesome.

There is no evidence in this experiment that voles prefer pitted to unpitted plants but the subsequent blanking of a planting is considerably simpler on a pitted than on an unpitted site.

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The following conclusions can be drawn from this experiment.

1. Percentage survival of open-rooted Pinus elliottii does not differ significantly from tray plants when planted into prepared pits. It is inferior to tray plants when planted without prior pitting.
2. Survival of open-rooted Pinus pinaster is significantly inferior to that of closed-rooted stock. The present system of planting closed-rooted stock into prepared pits gave significantly superior results to all other treatments tried for this species.
3. There are indications that pitting could be omitted for P.elliottii closed-rooted planting stock on areas which are being reafforested after clearfelling and burning.
4. The lifting of plants of P.elliottii from nursery trays for transporting and planting as open-rooted stock will only pay if weather conditions are favourable and distance to the planting site is considerable.

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APPENDIX 12.

THE EFFECT OF A PLASTIC ROOT-DIP ON OPEN-ROOTED PINE PLANTING STOCK IN THE MIDLANDS FOREST REGION OF THE CAPE.

Cost of afforestation in the Cape Midlands, with its white labour and expensive Nursery trays, is very high. With a view to reducing these costs a series of experiments has been designed to see if cheaper planting methods can be found. The experiment here described is one of this series.

The objects of this experiment were to determine if a plastic coating material applied as a root-dip would have any appreciable affect on the percentage survival and subsequent growth of open-rooted plants of the pine species normally used in this conservancy.

The plastic coating material which was used is a stable colloidal dispersion of a modified vinyl resin in water, and is sold under the trade name of Goodrite Latex V.L. 600. It is milk white in colour and dries at room temperature to a colourless film. Good results are claimed for it with an assortment of coniferous species under severe conditions, mostly from work done in the United States.

The site chosen for the experiment was the old nursery of Concordia Forest Station, which was abandoned on 31.3.1956. The site is a sun pocket during the day and a potential frost hollow at night.

The soil is of good depth (3') being a fine sandy loam on top with an increasing proportion of clay with increasing depth. The profile is immature and is probably to a large extent man made. Series 4, P.elliottii, is on a lower level than the other series and has a much stiffer loamy clay soil on the surface.

Having been only recently abandoned the nursery site was more or less free of vegetation. It was necessary,

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however, to cultivate the plots to a depth of 18" as the soil was very compacted. This was done three weeks before planting commenced.

Four Pinus species were used, each being given a series number:-

P.taeda	Series 1	P.radiata	Series 2
P.pinaster	Series 3	P.elliottii	Series 4

Three main treatments were applied to each species:-

A. Lifted from Nursery trays, shaken out, root-pruned and tied in bundles of 25.

B. As for A but dipped in a 1 in 4 solution of V.L.600 and water, and then dried before being bundled.

C. As for A but dipped in a 1 in 4 solution of V.L.600, to which the wetting agent Trition B. 1956 had been added, and dried before being bundled.

The concentration of V.L.600 used is that recommended by the makers and was kept constant. Trition B. 1956 is one of a number of wetting agents recommended for use with V.L.600, its purpose being to obtain a better and more continuous film.

It was found that 1 pint of V.L.600 when diluted with 4 pints of water was sufficient to dip 2500 - 3000 plants of normal nursery stock. The amount of Trition B.1956 recommended is 1 oz. per 100 gallons of water or approximately 4 drops per pint of V.L. 600 diluted 1 in 4.

In addition to the above treatments a time study varying the time between lifting and planting from 0 to 168 hours was carried out.

Table 1 gives a full list of treatments applied to each series.

All plants were trenched while awaiting planting.

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All time study plants were watered immediately after planting as were treatments 4-6. No water was applied to any of the plants either prior to planting or while in the trenches awaiting planting.

It had originally been intended to include a 1 hour variation in the time study but this was later dropped and treatments 7,8 and 9 were planted 72 hours after lifting.

Because heavy frosts were experienced on the nights of the 11th and 12th of June 1956, treatments13, 14 and 15 were planted approximately 20 hours instead of 12 hours after lifting.

The layout of the experiment took from the 11th to the 19th of June 1956. The Research Officer, Research Forester, a European labourer and a Coloured labourer were employed from the 11th to the 15th. The research personnel completed the work from the 16th to the 19th when the layout was completed.

With four men on the work it was found that the lifting, shaking out, root-pruning and dipping of 275 plants took just under 30 minutes. The undipped stock required 20 minutes to lift etc., bundle in 25's and trench. After dipping, plants were laid out separately on sloping sheets of corrugated iron to allow the plastic to dry. When dry they were collected in bundles of 25, tied and trenched in the same way as the undipped stock.

Time required for drying varied with the time of day dipping was carried out. Twenty minutes was found to be adequate during the middle of the day when the sun was hottest, but plants dipped in the later afternoon were found to be still damp after an hour.

This trouble was only experienced with P.elliottii, dipped in V.L.600 + wetting agent, where the plants were dipped late in the day.

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The average time required for planting each plot of 25 trees was 3 minutes for 4 men and five minutes for 2 men. The plots were too small to allow 4 men adequate space to work thus somewhat reducing the rate of planting.

TABLE I: GIVING LIST OF TREATMENTS APPLIED TO EACH SERIES.

SPECIES: PINUS TAEDA, PINUS RADIATA, PINUS PINASTER, P.ELLIOTTII.

Treatment No.	TREATMENT APPLIED TO OPEN-ROOTED PLANTING STOCK.
1.	25 plants root-pruned, and notch planted.
2.	25 " " " , dipped in V.L.600 and notch planted.
3.	25 " " " , dipped in V.L. + Wetting agent and notch planted.
4.	As for Plot 1 but watered immediately after planting.
5.	" " " 2 " " " " "
6.	" " " 3 " " " " "
7.	As for Plot 1 but planted 72 hours after lifting.
8.	" " " 2 " " " " "
9.	" " " 3 " " " " "
10.	As for Plot 1 but planted only 6 hours after lifting.
11.	" " " 2 " " " " "
12.	" " " 3 " " " " "
13.	As for Plot 1 but only planted 20 hours after lifting.
14.	" " " 2 " " " " "
15.	" " " 3 " " " " "
16.	As for Plot 1 but only planted 24 hours after lifting.
17.	" " " 2 " " " " "
18.	" " " 3 " " " " "
19.	As for Plot 1 but only planted 48 hours after lifting.
20.	" " " 2 " " " " "
21.	" " " 3 " " " " "
22.	As for Plot 1 but only planted 72 hours after lifting.
23.	" " " 2 " " " " "
24.	" " " 3 " " " " "
25.	As for Plot 1 but only planted 96 hours after lifting.
26.	" " " 2 " " " " "
27.	" " " 3 " " " " "
28.	As for Plot 1 but only planted 120 hours after lifting.
29.	" " " 2 " " " " "
30.	" " " 3 " " " " "
31.	As for Plot 1 but only planted 168 hours after lifting.
32.	" " " 2 " " " " "
33.	" " " 3 " " " " "

WEATHER CONDITIONS.

Unfortunately as no apparatus for accurate recordings was available only general weather conditions can be given. The following table reflects the conditions pertaining through the layout period.

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11.6.56. Fine and warm during the day, cloud nil. No wind. Very heavy frost during the night.

12.6.56. As for 11.6.56.

13.6.56. As for 11.6.56, but only light frost during the night.

14.6.56. Fine and warm during day, became overcast during night. No frost.

15.6.56. Fine and warm. Light Berg-wind blew during the day but dropped during the night.

16.6.56. Overcast but warm, occasional light breezes, clouds dispersed during night.

17.6.56. Warm and fine, cloud nil, no wind. Became overcast and colder during night.

18.6.56. Overcast and cold. Light showers of rain fell at 10 am. and 6 pm. Clear during the night.

19.6.56. Warm and fine, light Berg-wind. Became overcast in afternoon but still warm. Light showers fell at 5 p.m. Weather cleared during the night.

No frost was experienced during the period after 13.6.56.

Day temperatures at noon on those days when dipping was carried out is estimated to have been 65 - 70°F. and is thought not to have fallen below 55°F. during the period 11.6.56 to 19.6.56. Temperatures rose sharply around 10 am. and fell rapidly from about 4 pm. Night temperatures were very low in the early part of the period but rose again from the 15th of June.

Rainfall during the months of June and July was considerably lower than average and what rain did fall was widely scattered throughout the months so that its value was even more limited. Fortunately May had been an exceptionally wet month and the soil was still quite damp when planting commenced.

Rainfall during May, June, July and August was:

May	177.8 m.m.	(7.01")		
June	22.5 mm.	(.89")	6th. 5.0 mm.	8th 8.5 mm.
				26th 9.0 mm.
July	18.0 mm.	(.71")	4th.,5th and 6th	15.5 mm.
August	51.9 mm.	(2.05")		29th 2.5 mm.

Light Berg-winds were experienced on 15th and 19th during the layout of the experiments, but no strong Berg-winds blew during June or July.

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RESULTS.

An enumeration for percentage survival and percentage height increase was carried out during November 1956, five months after planting.

The results of this experiment were found to be somewhat different to those expected. It was thought that plants of the various treatments would show a fall off in percentage survival with increasing periods of trenching. This, however, was not the case, plants planted after seven days in the trenches gave as good a percentage survival as those planted immediately after lifting. To test this hypothesis an analysis of variance was done, treating the eleven time intervals as replicates of the three basic treatments. The analysis of variance is given below:-

S. of V.	D.F.	S.S.	M.S.	F.
Replicates (Time)	10	1764.9	176.49	1.26 N.S.
Species	3	29320.8	9773.60	69.78**
Treatments	2	18931.2	9465.60	67.57**
S x T	6	36191.2	6031.87	43.06**
Error	110	15407.5	140.07	-
Total.	131	101615.6	-	-

SUMMARY OF ANALYSIS (% Survival).

Species	A No.treatment	B dipped V.L.600	C dipped V.L.600 + T.B. 1956.	Species Means.
P.taeda	99.6	78.2	86.9	88.2
P.radiata	100.0	99.6	97.5	99.0
P.pinaster	100.0	99.3	99.3	99.5
P.elliottii	97.5	6.9	84.0	62.8
Treatment Means.	99.3	71.0	91.9	87.4

	S.E.	Significant P = 05	Difference P = 01
Body of Table	4.77	13.4	17.7
Species	2.06	5.8	7.6
Treatments	1.78	5.0	6.6

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It is clear that the use of V.L. 600 applied as a dip for open-rooted pine stock is not beneficial. The drying period essential for the formation of the protective plastic coat apparently allows the roots to dry out. The addition of a spreading agent, which ensures a thinner but more even and complete covering of the material, reduces this root desiccation considerably, but not completely.

The effect of the treatments tried therefore has been to increase the exposure of the roots by approximately twenty minutes over and above the exposure received by the untreated or control stock. This period was also about twenty minutes so the period of exposure to which treatment B and C were exposed was roughly forty minutes. This period has no effect on % survival of P.radiata or P.pinaster but affects both P.taeda and P.elliottii adversely. These results agree quite well with work by Slocum and Maki (1956) who found that open-rooted P.taeda was only significantly affected by periods greater than 30 minutes. Work by the author on P.radiata indicate that this species can stand exposure of at least one hour without affecting percentage survival, though this period significantly increases the period of check before growth recommences.

An extra bundle of 25 plants of each of the four species which had been given treatments A and C, were left in the trenches after the layout had been completed.

These plants were planted out on the 7.7.56, 23 and 22 days after lifting.

Percentage survival on 7.11.56 was:-

Treatment.		P.taeda	P.radiata	P.pinaster	P.elliottii
Undipped	(a)	100	100	100	44
Dipped in V.L.600 + T.B.1956	(c)	100	100	100	8

The same method of analysis was used for percentage

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height increase. Here the time replicates do differ significantly but there is no definite trend in the results and the decision to treat them as replicates of the main treatments seems justified.

ANALYSIS OF VARIANCE (Height Increase).

S. of V.	D.F.	S.S.	M.S.	F.
Replicates (Time)	10	1674.57	167.46	8.3**
Species	3	60497.28	20165.76	999.8**
Treatments	2	19846.00	9923.00	492.0**
S x T	6	10059.13	1676.52	83.1**
Error	110	22182.87	20.17	-
TOTAL	131	114259.85	-	-

SUMMARY OF ANALYSIS (% Height Increase).

	A No Treatment.	B Dipped V.L.600	D Dipped V.L.600 + T.B. 1956.	Means
P.taeda	95.1	31.9	63.0	63.3
P.radiata	10.3	5.5	6.6	7.4
P.pinaster	41.4	16.5	22.6	28.8
P.elliottii	28.0	1.0	17.3	15.4
Means	43.7	13.7	27.3	28.2

	Standard Error	Significant Differences P = 05	P = 01
Body of Table	1.354	3.8	5.0
Species	.78	2.2	2.9
Treatments	.68	1.9	2.5

The trenching of open-rooted stock has no significant effect on the initial growth of the stock after planting, and can be regarded as a reliable practice within the period of one week.

The effect of the treatments, that is the effect of approximately doubling root exposure, is very marked with all species, reducing the percentage height growth by approximately $\frac{2}{3}$ when compared with untreated stock.

The differences in percentage height increase between species are considered due to the inherent flushing times for the species themselves, and not caused by the treatments applied.

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Of the four pines here tried, P.taeda commences growth in the Cape Midlands before any of the others while P.radiata is invariably the last to flush.

The following conclusions can be drawn from this experiment.

1. The plastic coating material V.L.600 applied as a dip for the protection of open-rooted pine plants cannot be recommended.
2. Increased root exposure, which may or may not significantly affect the percentage survival of the stock, significantly increases the period of check before growth recommences.
3. Dormant open-rooted planting material of the four pine species used in this experiment can be trenched for periods of up to one week without affecting percentage survival or initial recovery of the plants. There is some evidence that P.taeda, P.radiata and P.pinaster can be left trenched for as long as three weeks without harm. P.elliottii, however, should not be left longer than seven days in the trench.

References:

Slocum, G.K. & Maki, T.E. 1956: "Exposure of Loblolly Pine Planting Stock". J. of For. 54:5 pp.313-315.

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APPENDIX 13.

A PILOT EXPERIMENT TO TEST DIFFERENT METHODS OF PLANTING FOR RE-ESTABLISHMENT OF CLEARFELLED FOREST GROUND.

An experiment to determine if the cost of re-afforestation of pine sites in the Cape Midlands could be reduced by varying the planting technique was laid out in Concordia Forest Reserve during September 1955.

The following are the planting methods which were tried:-

A. Normal planting from nursery trays into prepared pits.

B. Trowel planting from nursery trays without prior pitting.

C. Planting open-rooted plants, using a spade, without prior pitting.

The site for this experiment was Compartment B3b Concordia. The aspect of the compartment is northerly and the slope steep. Soil is a light sandy loam of good depth. The previous crop, which was a mixture of P.pinaster, P.elliottii and Acacia melanoxylon, was clearfelled in 1953/54. In July 1955 the slash was burnt and the site pitted for replanting with P.radiata at an espacement of 7' x 7'. The total area of the compartment is 24.8 acres, approximately twelve acres being planted by method A, methods B and C having about six acres each.

In March 1956, six months after planting, the various treatments were enumerated for percentage survival using a systematic sampling technique and covering 10% of the crop. Percentage survival of the three methods was:-

(a) 95.6% (b) 92.3% (c) 78.5%

The open-rooted section of the experiment required blanking, this operation being completed in April 1956, again using open-rooted planting material.

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Growth of trees planted by methods A and B began almost at once, but method C had a pronounced period of check lasting between four and five months.

A summary of the unit costs of the different methods is given below:-

A.	No. of units per 1000 plants planted (No. of plants per unit 316)	= 3.16 units.
	No. of units per 1000 pits prepared (No. of pits per unit 102)	= 9.80 units.
	No. of units per 1000 plants for transport from Nursery to planting site. (2 miles).	= 0.04 units.
	Total	13.00 units.
B.	No. of units per 1000 plants planted (No. of plants per unit 218)	= 4.59 units.
	No. of units per 1000 plants for transport from Nursery to planting site.	= 0.04 units.
	Total	4.63 units.
C.	No. of units per 1000 plants planted (No.of plants per unit 251).	= 3.98 units
	No. of units to blank 21.5% failure (No. of plants per unit 460).	= .50 units.
	No. of units per 1000 plants lifted and root pruned in the nursery.	= 0.06 units.
	No. of units per 1000 plants for transporting from Nursery to planting site.	= 0.04 units.
	No. units to lift and root prune plants for 21.5% failure per 1000 plants.	= .01 units.
	Total	4.59 units.

The high unit cost for method C, can be attributed to the unfamiliarity of the labour with the technique of open-rooted spade planting. The high percentage failure of this method is also partly attributable to this but more to the unfavourable aspect of the site. Cost of transport is regarded as a constant and is excluded from the above costs as the

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vehicle had to make one trip only with each type of planting stock, even though it was nearly empty when carrying the open-rooted plants. Transport costs for open-rooted plants will drop considerably as the number of plants and the distance to the planting site increase.

In January 1962, just over six years after planting a temporary sample plot was laid out in each planting method to determine if differences in growth rate still existed.

There was no visible difference in the three different sections of this stand, canopy was closed throughout and the whole compartment appeared to be uniform. This impression is confirmed by the data from the temporary sample plots, given below.

	Normal planting	Trowel planting without prior pitting.	Open-rooted Spade planing.
Stocking per acre	460	390	450
Mean height of Stand	38'	38'	38'
Mean D.B.H. of Stand	4.9	5.1	5.3

Two important points arise from these results:-

1. The long check of four to five months suffered by open-rooted planting material is not lasting and can be made up, in approximately six years.
2. The use of open-rooted planting material both for planting and blanking operations is satisfactory, giving results similar to the more orthodox techniques.

The very poor quality of the European labour employed at Concordia is reflected in the unit rates for the various operations which are appreciably lower than normal.

It would appear, however, that the cost of reafforestration in the Cape Midlands could be appreciably reduced, at least for Pinus radiata, on sandy loam soils. This species

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grows equally well when planted from nursery trays without pits or spade planted open-rooted without pits, though in the latter case blanking may be required. Even with labour completely unaccustomed to the technique, the open-rooted method is the cheapest and with labour used to it, planting costs can be reduced to under two units per 1000 plants or approximately one unit per acre, excluding transport costs.

Where P.radiata tray plants have been raised or are purchased for re-afforestation work, cost of establishment can be appreciably and safely reduced by planting without pitting. Even on sites where natural vegetation regrowth is likely to be troublesome row slashing during the first summer is a cheaper operation than pitting and may be economically preferable.

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APPENDIX 14.

COMPARISON BETWEEN THE USE OF OPEN-ROOTED PLANTS FROM BEDS AND PLANTS FROM TRAYS FOR AFFORESTATION WITH PINUS RADIATA.

In 1957 Thesens & Co., of Knysna laid out a small experiment to test the feasability of using bed-raised open-rooted plants for new planting on their ground in the Ruigtevlei area near Knysna.

The test consisted of 1000 tray plants and 1000 bed-raised open-rooted plants planted in adjoining areas on the Company's ground at Kerwelsvlei. The soil of this area is a deep sandy loam to sand typical of the old dune country lying along the coastal strip between Knysna and George. The aspect of the site is easterly and lies on the side of a hill, slope being flat at the bottom and top of the experimental section and very steep in the middle. Both types of plants were planted into prepared pits with trowels.

In January 1962, approximately 3½ years after planting, the area was visited to see if growth differences were evident. The two types appeared remarkably uniform, there being no visible differences. To confirm this and to obtain percentage survival data a systematic sample was taken to cover the three different slopes on the area. The following data was obtained.

1. Percentage survival (5% sample)

   Tray plants 2% death, open-rooted plants 6% death.

2. Growth (3% Sample per section)

	Tray	Open-Rooted
i) Over area as whole		
Mean DBH	2.6"	2.7"
Mean Height	16½'	16'
ii) Bottom Section (flat)		
Mean DBH	3.1"	3.2"
Mean Height	19½'	18'
iii) Mid Section (Very Steep)		
Mean DBH	2.2"	2.5"
Mean Height	15'	14'

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iv) Top Section (flat)	Tray	Open-Rooted
Mean DBH	2.4"	2.4"
Mean Height	15½'	15'

From the above it is evident that on the sandy soils and cooler aspects of the Knysna region P.radiata raised in beds and planted open-rooted can give equivalent results both for percentage survival and rate of growth to tray plants .

Thesens are now using bed-raised open-rooted P.radiata planting material for all new plantings except for those sites with northern aspects.

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APPENDIX 15.

THE EFFECT OF DIFFERENT NURSERY SOWING METHODS ON OPEN-ROOTED PINUS RADIATA PLANTING MATERIAL.

An Experiment was laid out at Elgin Nursery in December, 1961 to determine:-

i) if open-rooted Pinus radiata plants could be raised satisfactorily from direct sowing in nursery beds;

ii) if drill or broadcast sowings were preferable and

iii) to compare both these methods with the standard method of sowing thickly, followed by pricking out when the stock is a satisfactory size.

In addition a further variable to compare surface sown, plastic covered sowings with the standard ¼" sand covered sowings was introduced.

The variables can be summarised:-

A. Method of Raising (3)

0 Densely sown and later pricked out

1 Broadcast sown in situ

2 Drill sown in situ

B. Method of Sowing (2)

0 Standard practise - seed covered with approximately ¼" sand.

1 Seed sown on surface and pressed in, covered with 300 gauge clear plastic sheet.

Layout was a randomised block, six treatments and three replications. The plants were raised in 12' x 3' open beds contained by 4" x 1" planks, the bottom of the planks being planed to facilitate root pruning. Normal nursery soil was used for this experiment but because of the lateness of the season all soil was sterilised with methyl bromide to prevent damping off losses. Broadcast and drill sowings were sown directly into the beds while sowings for pricking out were sown into nursery trays and the plants pricked out into the beds.

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All treatments were sown on 7.12.1961. Sand coverings were made in the usual way. Surface sown seed was placed upon a roughened soil surface and tamped down, clear 300 gauge plastic was then placed on top. It had previously been found that temperatures under clear plastic often rise to 50-55°C, during the summer months from November to February. As this temperature is lethal to germinating seeds of Pinus radiata a lathe screen was placed over all sowings to keep temperatures within favourable limits.

Germination under the plastic sheeting was rapid and sheets had to be removed from the box sowing by the 18.12.1961. Bed sowings were somewhat slower as the plastic sheets did not fit over the beds as neatly. Nevertheless all plastic had been removed by the 24th December 1961. Germination from standard sowing method began at the same time as that under plastic but was more spasmodic and was not completed until the 1st week in January 1962.

All pricking out was done between the 23rd and the 25th of Jan. 1962. The sown plots were first root pruned on 23rd January 1962. All plots were root pruned on 18th of February and monthly there after until 18.6.1962 when plants were lifted and transported to Lebanon forest reserve, approximately 10 miles from the nursery, for planting trials. At time of planting all useable plants were counted and a random sample of ten plants from each plot was brought into the laboratory for shoot length, dry weight, Root Shoot ratio and collar diameter measurements. The results, where significant, are given below:-

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Analysis of Varience.

		Length of Shoot			No. of useable plants		
	D.F	S.S.	M.S.	F	S.S.	M.S.	F
Blocks	2	4.85	2.425	21.087**	108.11	54.055	81^{NS}
Method of raising	2	17.41	8.705	75.696**	36106.78	18053.39	24.082**
Method of sowing	1	.80	.80	6.957*	1760.22	1760.22	2.348^{NS}
MR x MS	2	.71	.355	3.087^{NS}	3286.11	1643.055	2.192^{NS}
Error	10	1.15	.115	-	7496.56	749.656	-
Total	17	24.92	-	-	48757.78	-	-

	Length of Shoot			No. of Useable plants		
		P. values			P. values	
	S.E.	0.1	0.5	S.E.	0.1	0.5
Method of Raising	.138	.62	.43	11.18	50.1	35.2
Method of Sowing	.113	.51	.36	not	significant	

Summary of Analysis.

Length of Shoot

	Pricked Out	Broad Cast Sown	Drill Sown	Means
tandard Sowing	4.33	6.83	6.10	5.75
urface Sown and plastic covered	4.83	6.73	6.96	6.17
Means	4.58	6.78	6.53	5.96

Number of Useable plants.

Pricked Out	Broadcast Sown	Drilled Sown	Mean
91.2	155.2	200.3	148.9

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The method of raising has no significant effect on the root shoot ratio or on the collar diameter of the plants but plant size and number of useable plants raised are significantly affected by the method of raising. Only plant size is affected by method of sowing and then only at the 5% level significance.

Direct bed sowing methods can be used with confidence for the production of open-rooted Pinus radiata plants. There seems to be little value in the pricking out operation. The check suffered by the plant is appreciable and although shoot growth suffers, root growth is no better than for root pruned sown stock, the root shoot ratio not differing significantly.

The seed used for this experiment was an average lot, the data for it being given below:-

Species: Pinus radiata	Stock No. (?)
%Purity	82.0%
No. of seed per lb.(cleaned)	16,457
% seed with full kernels	96.9%
Germinative capacity	90.6%

Quantity of seed sown was the same for each treatment and plot. It was calculated to give a stocking of 30 seedlings per sq. foot with an expected plant percent of 66.6%. The actual plant percentages recorded varied considerably with the method of raising but were appreciably lower than expected, probably due to the lateness of the sowings.

Plant percent.

Pricked Out	Broad Cast Sown	Drill Sown	Mean
22.8	38.8	50.1	37.2

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The following conclusions can be drawn from this experiment:-

1. Pricking out significantly reduces the number and size of plants produced (Both 1% level significance).
2. Broadcast and drill sowings produce planting material of similar quality but a significantly higher plant percent is obtained with drill sown seed. (5% level significance).
3. Plastic covered surface sowings germinated faster and more uniformly and produced larger plants in the six months period the plants were in the nursery. (5% level significance).

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APPENDIX 16

% BLANKING FOR 10 YEAR PERIOD 1949/50 to 1958/59*

Year	No. of plants used	Plants+ used for Blanking in the following year	Blank %
1949/50	10,798,920	2,403,553	22.2
1950/51	9,246,960	2,095,713	22.7
1951/52	11,408,940	2,921,300	25.6
1952/53	11,435,040	2,699,156	23.6
1953/54	13,860,720	2,660,981	19.2
1954/55	14,642,640	2,344,000	16.0
1955/56	13,502,700	3,061,949	22.7
1956/57	15,940,260	3,800,974	23.8
1957/58	17,406,900	4,945,355	28.4
1958/59	11,950,200	5,034,811	42.1

Mean % Blanking required for the period 24.6%

Mean % Survival for the period 75.4%

* Data extracted from Annual Reports of Department of Forestry.

+ All species.